APPENDIX A
UWB EMI TEST PLAN FOR THE AN/ARC-210 VHF AM MODE

1.0 INTRODUCTION

The AN/ARC-210 very high frequency/ultra high frequency (VHF/UHF) Communication System is a line-of-sight; multi-mode transmitter/receiver system incorporating advanced electromagnetic counter-counter measures (ECCM). The AN/ARC-210 emulates the Single Channel Ground and Airborne Radio System (SINCGARS) in the VHF band (30 MHZ to 88 MHz) and emulates the HAVE QUICK radio in the UHF band (225 MHz to 400 MHz). The AN/ARC-210 uses frequency modulation (FM) in the 30 MHz to 88 MHz band and both amplitude modulation (AM) and FM in the 225 MHz to 400 MHz band. In addition, the radio is capable of providing AM operation in the 108 MHz to 156 MHz band and FM operation in the 156 MHz to 174 MHz band. The nominal sensitivity of the receiver is –103 dBm for AM operation and –108 dBm for FM operation. The system can operate in either fixed frequency or frequency-hopping modes with 25 kHz channel spacing. This test plan is for the AN/ARC-210 operating in the VHF AM Mode in the frequency band from 108 MHz to 156 MHz.

2.0 OVERALL TEST OBJECTIVE

The overall objective of the test is to determine the electromagnetic interference (EMI) susceptibility of the AN/ARC-210 (operating in the VHF AM Mode) to conducted ultra-wideband (UWB) signals that are injected into the receiver antenna port. The results of this investigation will provide the information necessary to evaluate the potential for UWB signals to interfere with the AN/ARC-210 and to understand how UWB systems could be implemented to make use of their unique capabilities without causing EMI.

3.0 TEST APPROACH

In order to accomplish the test objective, there are several parameters that must be measured. These parameters are the sensitivity of the receiver to the desired signal and the susceptibility of the receiver to noise and selected UWB interfering signals. The test will be performed for the receiver operating in both fixed tuned and frequency-hopping modes.

The tests will be performed at the Naval Air Warfare Center Aircraft Division (NAWC AD) Electromagnetic Environmental Effects (E^3) facility by personnel that are familiar with EMI test equipment and are knowledgeable about EMI test procedures and techniques. For the type of scientific testing required for this project, detailed “cookbook” test procedures may be too restrictive and may impede testing. Therefore, detailed test procedures are not considered to be necessary and will not be provided in this test plan. Instead, the plan outlines procedures that will be dynamically adapted during the tests and recorded to ensure consistency and repeatability.

4.0 UWB WAVEFORMS

The UWB waveform parameters that will be used for the AN/ARC-210 receiver shall be selected from the set of waveforms that are presented below. When a filtered baseband pulse waveform is used, the frequency band for the UWB signal shall be selected so the receiver operating band (108 MHz to 156 MHz) falls within the UWB signal band. When the waveform is generated by an unfiltered baseband pulse, the selection of the frequency band does not apply.

The first five waveforms described below should provide the most EMI impact on a receiver. If none of the first five waveforms produce significant EMI impact on the EUT, the impact with other waveforms will be negligible and the testing can end at this point. If any of the first five waveforms result in EMI, additional testing shall be performed using waveforms 6 and 7 to provide a better characterization of the impact.

After completion of testing for the victim specific waveform, each victim will be tested using both of the generic phase shift UWB "Communication" Waveforms, Waveforms 8 and 9, and the generic On-OFF Keying (OOK) UWB "Communication" Waveforms, Waveform 10. These waveforms have been designed to simulate idealized actual UWB communications code schemes and will provide an indication of the EMC of such special codes.

4.1 Test Waveform One (TW1)

For the first test waveform, the pulse repetition frequency (PRF) shall be the maximum value available from the pulse generator that results in the fundamental or a harmonic of the PRF falling within the tuning bandwidth of the receiver.[1] For the AN/ARC-210 operating in the VHF AM Mode, the test frequencies will be 112.8 MHz, 132 MHZ and 151.2 MHZ. The corresponding PRFs for the first test waveform shall be equal to 56.4 MHz, 66 MHz and 75.6 MHz respectively. This first test waveform shall not be dithered or modulated. For this case, only one spectral line will fall within the intermediate frequency (IF) passband and the IF signal will appear to be a continuous wave (CW) signal. The receiver shall be tuned to the spectral line.

4.2 Test Waveform Two (TW2)

For the second test waveform, the basic PRF shall be the same as described for the first test waveform. However, the pulses shall be randomly dithered to fill 50% of the IF passband. This will result in a noise like signal in the IF passband and the receiver shall be tuned for maximum impact from the UWB signal.

[1] Note that the reference frequency for the UWB pulse generator is the PRF. Therefore, the terms fundamental and harmonic refer to the fundamental and harmonics of the PRF.

4.3 Test Waveform Three (TW3)

For the third test waveform, the PRF shall be 25 kHz. The pulses shall be dithered randomly to fill 100% of the IF passband. This will result in a noise like signal across the tuning range of the receiver.

4.4 Test Waveform Four (TW4)

For the fourth test waveform, the PRF shall be 25 kHz. The signal shall not be dithered but the waveform shall be modulated with on-off keying (OOK). This type of UWB interfering signal will result in a modulated signal in the IF passband and the receiver shall be tuned for a maximum impact from the UWB interference.

4.5 Test Waveform Five (TW5)

For the fifth test waveform, the PRF shall be 2.5 kHz. The waveform shall not be modulated or dithered. For this case, the PRF will be slow relative to the IF response time so the individual pulses will appear in the IF (however, the pulse width will be increased and the peak power will be reduced). For this waveform approximately 10 spectral lines will fall within the IF passband.

4.6 Test Waveform Six (TW6)

For the sixth test waveform, the PRF shall be 250 kHz and the pulses shall not be dithered or modulated. For this case, the PRF will be fast relative to the IF response time. Therefore, the signal will appear to be continuous and the effect will be that of a CW signal. Only one spectral line can fall within the IF passband and there should be a spectral line in every tenth channel. To the extent possible the receiver shall be tuned to the spectral line closest to the designated test frequency.

4.7 Test Waveform Seven (TW7)

For the seventh test waveform, the PRF shall be 250 kHz and the pulses shall be dithered randomly to cover 25% of the IF bandwidth. This will result in a noise like signal in the IF passband for every tenth channel and the receiver shall be tuned for a maximum impact from the UWB waveform.

4.8 Test Waveform Eight (TW8)

The eighth test waveform is a stream of doublets with random initial phase orientation. The value of the symbol is determined by the phase relationship of the two pulses in the doublet as shown in Table 1. The two pulses in the doublet are separated by about 1 ns. Doublets themselves have burst repetition interval (BRI) of about 267 ns apart, allowing for a data rate of about 3.75 Mb/s for a high data rate or about 15.625 μs apart, allowing for a data rate of about 64 kb/s for a low data rate. The high data rate timing retains the ratio of peak to average spectral density described in the recent FCC ruling.

Table 1. Pseudorandom Noise Doublet Symbol Mapping

	Data = 0	Data = 1
PN = 0	+ +	+ -
PN = 1	- -	- +

Data is sent in packets of 1200 bits. This includes 1024 of payload data plus 176 bits of header. High data rate packets would be sent at the 3.75 Mp/s rate and last 320 µs. The packets would occur once every 8 ms and the packets would occur once every 8 ms. Low data rate packets would be sent at the 64 kp/s rate and last 18.75 ms and the packet would occur once every 468.75 ms. The payload data would be random, or all ones, or all zeros. The header data would be the same for each packet. Use all ones or all zeros for the header.

4.9 Test Waveform Nine (TW9)

The ninth test waveform is a stream of doublets with fixed initial phase orientation. The value of the symbol is determined by the phase relationship of the two pulses in the doublet as shown in Table 2. The two pulses in the doublet are separated by about 5.708 ns. Doublets themselves have burst repetition interval (BRI) of about 17.123 ns apart, allowing for a data rate of about 58.4 Mb/s. The code has a maximum length 0f 1023 bits. This pulse spacing provides a spectrum with nulls every 175.2 MHz.

Table 2. Constant Phase Doublet Symbol Mapping

DATA	SYMBOL
0	- +
1	+ -

This waveform has three data rates based on the initial 58.4 Mb/s base data rate. The high data rate is simply a continuous stream at this rate. The medium data rate sends a burst of 1023 random symbols with a 175.17 µs BRI for a 10% burst duty factor. The low data rate sends a burst of 1023 random symbols with a 1.7517 ms BRI for a 1% burst duty factor.

4.10 Test Waveform Ten (TW10)

The tenth test waveform is an OOK pattern. Bit spacing is about 5 ns. Every 206 µs a training preamble of constant data rate pulses is sent. There is only one data rate for this waveform.

5.0 RECEIVER SUSCEPTIBILITY TEST

The objective of the receiver susceptibility tests is to obtain data that will provide useful information on the susceptibility of AN/ARC-210 receivers to UWB interference. The tests will be performed using either one or two signals. With the one signal tests, a UWB interfering signal is input to the receiver under test and the output is observed. The receiver is considered to be susceptible if the UWB interfering signal produces a detectable change in the receiver output. No intended in-band signal is used for this test. For the AN/ARC-210, the concern is that EMI may cause changes in the output of the receiver that will impact the desired functionality of the received signal. The changes in the output of the receiver may be manifested as: a change in the output noise; the production of interference at the output; or, activation (of the automatic gain control, etc).

The two signal susceptibility tests described in this test plan require that the receiver desired signal and a UWB interfering signal be simultaneously injected into the receiver antenna port. The concern is that EMI can degrade the performance of the AN/ARC-210. The baseline performance is defined in terms of a standard response that is used to determine receiver sensitivity and provides the basis for the susceptibility tests. For the AN/ARC-210, the standard response is usually defined in terms of a signal to interference, noise, and distortion (SINAD) ratio or a bit error rate (BER). The sensitivity is measured before the susceptibility tests are performed.

There are two approaches that may be used for the two signal susceptibility tests. For the first approach, the desired signal level is fixed at a level that is 6 dB above the standard response level and the receiver susceptibility to UWB interference is determined by slowly increasing the UWB signal strength until the receiver can no longer maintain a standard response. The susceptibility level describes the effect of the UWB interfering signal when the desired signal is close to the standard response level.

For the second approach, a high level UWB interfering signal (e.g., 20 dB above the receiver sensitivity) is injected and the desired signal level that is required for satisfactory operation of the receiver is determined. The information obtained from this test may be used to determine the reduction in range that the receiver will experience as a result of UWB interference. These levels are a better indication of the degradation resulting from UWB interference when the receiver has significant desired signal to operate with and is more typical of normal operations.

5.1 Receiver Sensitivity Measurement – Fixed Frequency Mode

The receiver sensitivity level is specified as the signal level required creating an appropriate standard response that results in satisfactory operation of the receiver. For operation of the AN/ARC-210 in a fixed frequency mode, the standard response is the level that results in a SINAD equal to 10 dB. The receiver sensitivity is measured using an on-tune desired signal that contains the normal receiver modulation.

5.1.1 Receiver Sensitivity Measurement – Fixed Frequency Mode Objective

The objective of this test is to determine the sensitivity of the AN/ARC-210 receiver operating in a fixed frequency mode.

5.1.2 Receiver Sensitivity Measurement – Fixed Frequency Mode Test Set-Up

The test set-up diagram for the receiver sensitivity test is shown in Figure 1.

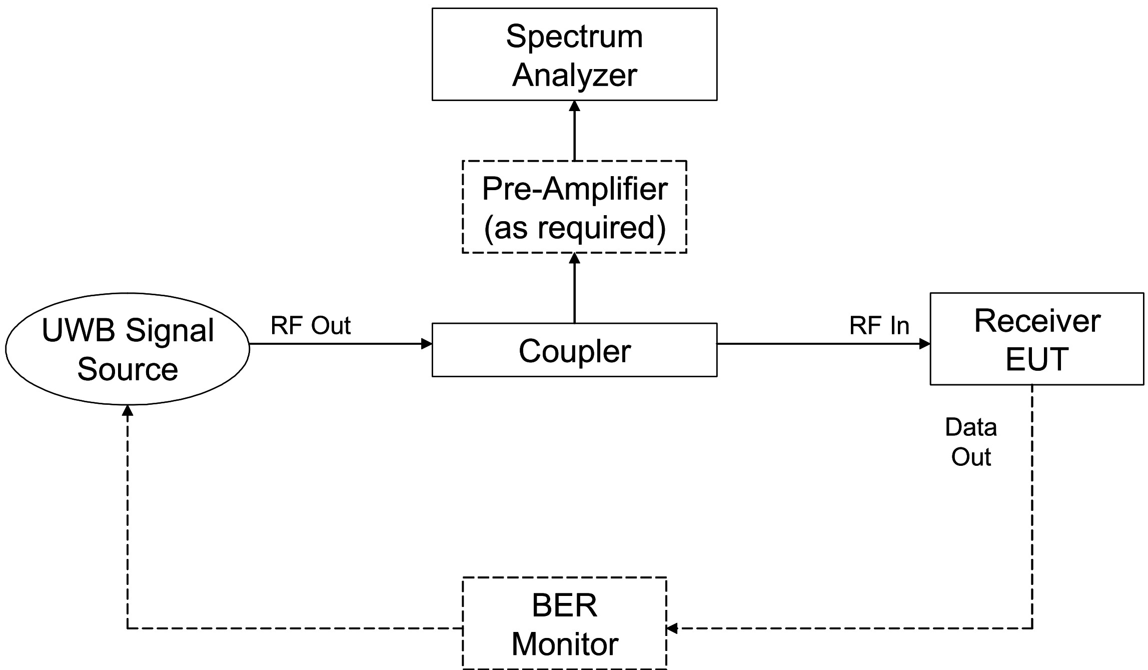

Figure 1. Receiver Sensitivity Test Set-Up

A signal generator or a signal simulator is used to generate the signal used for the test. A spectrum analyzer is used to monitor and measure the signal level at the input to the receiver EUT. A pre-amplifier connected at the input of the spectrum analyzer may be required to observe the signal during the sensitivity test. Alternatively, after the sensitivity level is established, the signal level can be raised by a known, fixed amount (e.g., 40 dB) to enable the spectrum analyzer measurement to be made.

Spectrum analyzer levels shall be corrected for the pre-amplifier gain (if used) plus coupler and/or cable losses that exist in the measurement system. The receiver operation is verified to be satisfactory by monitoring the receiver output and/or measuring the BER of the information data.

5.1.3 Receiver Sensitivity Measurement – Fixed Frequency Mode Test Procedure

The general test procedure for determining receiver sensitivity for operation in a fixed frequency mode is as follows:

1. Tune the receiver to a test frequency. Set the desired signal simulator to the tuned frequency of the receiver and adjust the output power to a level that is at least 10 dB below the receiver nominal sensitivity. The simulator signal shall be modulated in the normal manner used by the receiver and, if appropriate, coded with the receiver's internal code. Verify that the receiver has not achieved a standard response condition for the low level signal.

2. Increase the signal simulator power level until the receiver standard response level is obtained (i.e., 10 dB SINAD). Be sure to pause between each increase in signal power by an amount exceeding the maximum specified settling time for the receiver. Record this as the "standard response acquisition threshold" (ACQ) on the data sheet in Table 3.

3. Increase the input power level an additional 10 dB above the ACQ.

4. Decrease the input power level until the standard response condition is impacted. Record on the data sheet (Table 3) the input power level at which loss of the standard response was first observed. This level is termed the "signal upset threshold" (SUPSET) level. It shall be noted that ACQ and SUPSET may occur at the same level.

5. Steps 1 through 4 shall be performed at frequencies of 112.8 MHz, 132 MHz and 151.2 MHz.

6. If the receiver operates at multiple modes/rates, repeat Steps 1 through 5 while the receiver is operating at several representative modes (e.g., if the receiver operates at several data rates, make the measurements with the receiver operating at minimum, maximum, and nominal data rates).

5.1.4 Receiver Sensitivity Measurement – Fixed Frequency Mode Test Output

The required results from the receiver sensitivity test consist of documenting the ACQ and SUPSET thresholds on the data sheet provided in Table 3. An average threshold value shall be specified if significant differences exist between the thresholds determined in the multiple test trials.

TABLE 3. DATA SHEET FOR SENSITIVITY MEASUREMENTS

Receiver: AN/ARC-210 VHF AM Mode
Frequency Band: 108 MHZ to 156 MHz
Receiver Modes: Fixed tuned
Test Frequencies: 112.8 MHz, 132 MHz, 151.2 MHz
Standard Response Criterion: 10 dB SINAD
Desired Signal Modulation: AM
IF Bandwidth: 25 kHz
Sensitivity: -103 dBm

RCVR FRQ (MHz)	RCVR MODE	ACQ (dBm)	SUPSET (dBm)	NOTES
112.8				
132				
151.2				

NOTE: Sensitivity threshold levels are inherently statistical and thus this procedure shall be conducted multiple times to obtain a representative sample of the threshold level. Tests shall be conducted at frequencies corresponding to 10%, 50% and 90% of the tuning band.

5.2 White Noise Test Method

The white noise susceptibility test method is performed by injecting a desired signal and a white noise signal, with the same or greater bandwidth as that of the victim receiver, directly into the receive antenna port and observing the impact at the output of the receiver.

5.2.1 White Noise Test Objective

The objective of this test is to determine the impact of white noise signals on a receiver and determine the susceptibility threshold as a function of the white noise signal parameters.

5.2.2 White Noise Test Setup

The test setup is shown in Figure 2.

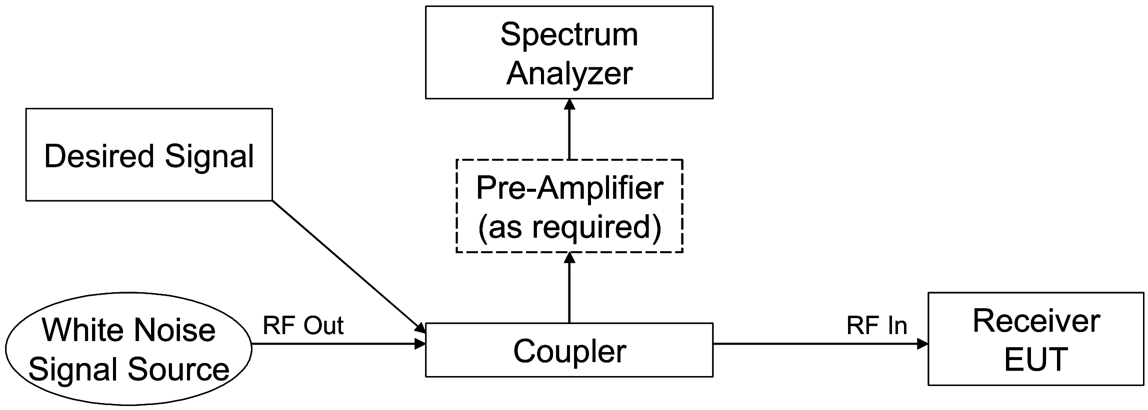

Figure 2. Set-Up for White Noise Susceptibility Test

5.2.3 White Noise Test Procedure

1. Set up AN/ARC-210 for fixed frequency operation in the VHF band.

2. Input the desired signal at a frequency of 112.8 MHz and at the standard response level.

3. Inject the white noise signal into the receiver input at a level that is at least 10 dB above the receiver standard response level. The noise level shall be high enough to mask the desired signal at the receiver output. The average noise level shall be measured using the spectrum analyzer with a resolution bandwidth of 1 kHz, 30 kHz or 1 MHz (or similar bandwidths). The bandwidth shall be selected so it is the highest of the three choices that is less than the receiver IF bandwidth. Empirical or calculated bandwidth correction factors shall be used to adjust the readings to the IF bandwidth of the receiver. Increase the desired signal level to obtain a standard response condition. Record the desired and noise interfering signal levels on the data sheet in Table 4.

4. Repeat steps 1 through 3 at frequencies of 132 MHz and 151.2 MHz.

5.2.4 White Noise Test Output

The test output will define white noise waveform conditions that result in EMI.

TABLE 4. DATA SHEET FOR WHITE NOISE TESTS

Receiver: AN/ARC-210 VHF AM Mode
Frequency Band: 108 MHz to 156 MHz
Receiver Mode: Fixed Tuned,
Test Frequencies: 112.8 MHz, 132 MHz, 151.2
Standard Response Criterion: 10 dB SINAD
Desired Signal Modulation: AM
IF Bandwidth: 25 kHz
Sensitivity: -103 dBm

	SIGNAL LEVEL (dBm)	**NOISE LEVEL (dBm)**
STANDARD RESPONSE LEVEL		**N/A**
LEVEL WHERE NOISE MASKS SIGNAL		
STANDARD RESPONSE LEVEL WITH NOISE		

5.3 One Signal Susceptibility Test Method

The one signal susceptibility test method is performed by injecting a UWB signal, with the appropriate waveform parameters as defined in Section 4.0, directly into the receive antenna port and observing the impact at the output of the receiver. If the receiver exhibits a change in the output as a result of the injected interfering signal, the receiver is considered to be susceptible. The change in the output may be manifested as a change in the output noise, the production of an interfering signal at the receiver output, activation of the receiver automatic gain control, etc.

5.3.1 One Signal Susceptibility Test Objective

The objective of this test is to determine the impact of UWB signals on a receiver and determine the susceptibility threshold as a function of the UWB signal parameters.

5.3.2 One Signal Susceptibility Test Setup

The test setup is shown in Figure 3.

5.3.3 One Signal Susceptibility Test Procedure

The procedure is to inject a UWB signal into the receiver input and observe the receiver output for any change that may provide an indication of susceptibility. Examples of indications of susceptibility are changes in the output noise, the production of an interfering signal at the output, activation of the receiver automatic gain control, etc. The tests shall be conducted for each of the applicable UWB waveforms identified in Section 4.0 and at each of the frequencies specified in Section 5.3. The UWB interference upset

(IUPSET) conditions that provided an indication of susceptibility shall be recorded in Table 5.

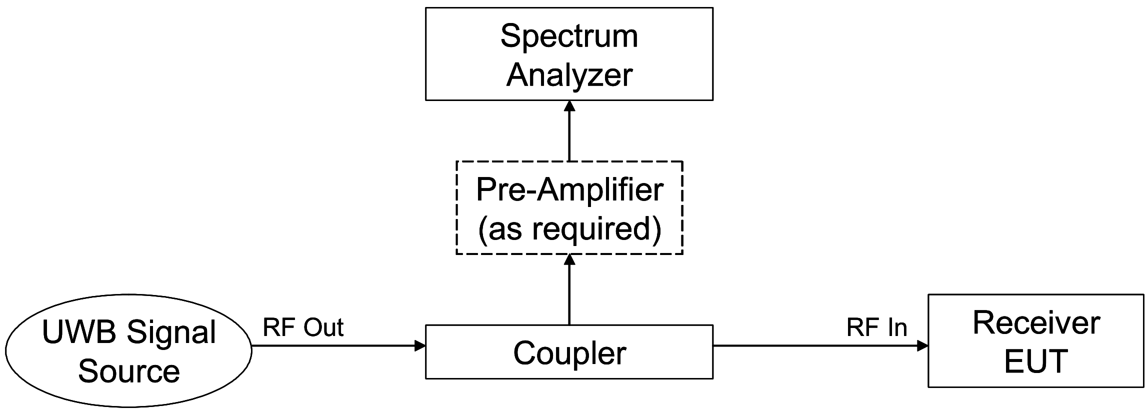

Figure 3. Setup For One Signal Susceptibility Test

TABLE 5
DATA SHEET FOR ONE SIGNAL SUSCEPTIBILITY TEST

Receiver: AN/ARC-210 VHF AM Mode
Frequency Band: 108 to 156 MHz
Receiver Mode: Fixed Tuned
Test Frequencies: 112.8 MHz, 132 MHz, 151.2. MHz
Standard Response Criterion: 10 dB SINAD
Desired Signal Modulation: AM
IF Bandwidth: 25 kHz
Sensitivity: -103 dBm

RX FRQ (MHz)	UWB SIGNAL	PRF (MHz)	UWB MOD	IUPSET (dBm)
112.8	1	56.4	NONE	
	2	56.4	DITHERED ± 8.75 kHz	
	3	0.025	DITHERED ± 17.5 kHz	
	4	0.025	OOK	
	5	0.0025	NONE	
	6	0.250	NONE	
	7	0.250	DITHERED ± 4.375 kHz	
	8	Low Duty Factor (LDF)	NONE	
	8	High Duty Factor (HDF)	NONE	
	9	LDF	NONE	
	9	Medium Duty Factor (MDF)	NONE	
	9	HDF	NONE	
	10	LDF	NONE	
	10	HDF	NONE	

Note that the spectrum analyzer resolution and video bandwidths will not be as wide as the RF bandwidth of the UWB waveform. The resolution bandwidth (RBW) of the spectrum analyzer shall be 30 kHz or the spectrum analyzer RBW closest to, but not exceeding, 35 kHz. The spectrum analyzer video bandwidth (VBW) shall be equal to or greater than the RBW. Empirical or calculated bandwidth correction factors shall be used to adjust the measurement of the UWB waveform to the IF bandwidth of the receiver. Average measurements shall be made for all of the test waveforms except for Waveform Five which shall be made as a peak measurement. Record the interfering signal conditions (signal parameters and levels) that cause an impact on the receiver output.

5.3.4 One Signal Susceptibility Test Output

The test output will define UWB waveform conditions that result in EMI.

5.4 Two Signal Susceptibility Test - Fixed Frequency – Standard Response Desired Signal

5.4.1 Two Signal Susceptibility Test - Fixed Frequency – Standard Response Desired Signal Test Objective

The objective of this EMI test is to determine the susceptibility of an AN/ARC-210 receiver to UWB interfering signals. Susceptibility thresholds will be determined by monitoring the output of the receiver and/or measuring the BER for the information data.

5.4.2 Two Signal Susceptibility Test - Fixed Frequency – Standard Response Desired Signal Test Setup

The test setup is shown in Figure 4.

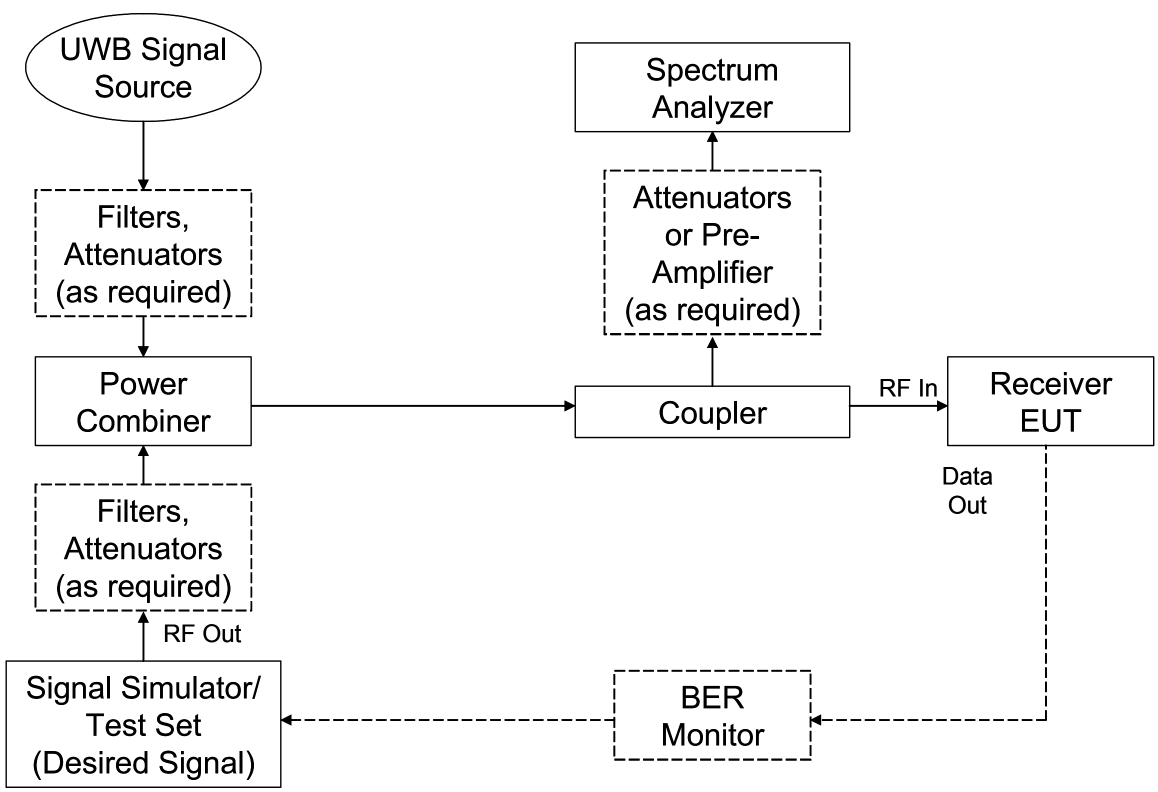

Figure 4. Conducted Susceptibility Test Set-Up-Two Signal Method

5.4.3 Two Signal Susceptibility Test - Fixed Frequency – Standard Response Desired Signal Test Procedure

The two signal susceptibility test procedure should define the performance impact that a receiver will sustain as a result of EMI from a UWB signal. In order to obtain meaningful results, it is necessary to use a desired signal level that is sufficiently above the receiver noise level to minimize the impact of receiver noise on performance.

The receiver standard response level is often defined in terms of the signal level required to produce a SINAD equal to 10 dB at the output of the receiver. If there is no interference or distortion, the 10 dB SINAD translates to a 10 dB signal-to-noise ratio. If a noise like interfering signal at the receiver noise level is added to the receiver input, the SINAD would decrease by 3 dB (i.e. from 10 dB to 7 dB). This is too close to the receiver noise and the test results may be affected by the receiver noise as well as by the UWB interference. If the desired signal is 10 dB above the receiver noise, a noise like EMI signal at the noise level would have little impact on performance. As a result of the factors discussed, it was decided that a desired signal level that is 6 dB above the standard response level should be used for testing.

The general test procedure for determining receiver susceptibility to interference when the desired signal is 6 dB above the standard response level and the receiver is operating at a fixed frequency is as follows:

1. Tune the receiver to a test frequency of 112.8 MHz. Set the desired signal to the test frequency. Adjust the desired signal to a level that is 6 dB above the ACQ as measured in Section 5.2. Verify that the receiver output exceeds a standard response condition (i.e., SINAD is greater than 10 dB).

2. Decrease the desired signal until the level is 6 dB above the SUPSET. Record this level in Table 4 as the "desired signal level" (DSL) for the selected UWB waveform used for the tests. Verify that the receiver output exceeds the standard response condition.

3. Activate the UWB interference signal source with one of the UWB test waveforms at a level that is 20 dB below the SUPSET level recorded in Section 5.2.

4. Increase the interference signal power level until there is an indication of impact on the receiver standard response condition (i.e., a decrease in the SINAD). Record this level as the UPSET level in Table 6. Record IUPSET – DSL as the interference-to-signal ratio (I/S).

5. Set the desired signal level to 6 dB above the acquisition threshold level. Record this level as the DSL on the second row for the selected UWB waveform. Set the UWB interfering signal to the maximum level available. Decrease the UWB

interference signal power until the receiver returns to a standard response condition and all parameters are within acceptable limits. Record this interference level in Table 6 as the “interfering signal reacquisition threshold” (REACQ) level. Record REACQ – DSL as the I/S ratio.

6. Repeat Steps 1 through 5 for each of the UWB test waveforms.

7. Repeat Steps 1 through 6 for receiver operating frequencies of 132 MHZ and 151.2 MHz.

5.4.4 Two Signal Susceptibility Test - Fixed Frequency – Standard Response Desired Signal Test Output

The required results from the two signal EMI tests consist of recording the desired signal level (DSL), the interfering signal level for the IUPSET and REACQ and the I/S ratio on the appropriate line on the applicable data sheet for the UWB interference signal modulations and receiver modes of operation.

TABLE 6. TWO SIGNAL SUSCEPTIBILITY TEST WITH DESIRED SIGNAL AT STANDARD RESPONSE LEVEL

Receiver: AN/ARC-210 VHF AM Mode
Frequency Band: 108 MHz to 156 MHz
Test Frequencies: 112.8 MHz, 132 MHz, 151.2 MHz
Receiver Mode: Fixed Tuned
Standard Response Criterion: 10 dB SINAD
Desired Signal Modulation: AM
IF Bandwidth: 25 kHz
Sensitivity: - 103 dBm

RX FRQ (MHz)	UWB SIGNAL	PRF (MHz)	UWB MOD	DSL (dBm)	IUPSET (dBm)	REACQ (dBm)	I/S (dB)
112.8	1	56.4	NONE			X	
	1	56.4	NONE		X		
	2	56.4	DITHERED ± 6.25 kHz			X	
	2	56.4	DITHERED ± 6.25 kHz		X		
	3	0.025	DITHERED ± 12.5 kHz			X	
	3	0.025	DITHERED ± 12.5 kHz		X		
	4	0.025	MODULATED			X	
	4	0.025	MODULATED		X		
	5	0.0025	NONE			X	
	5	0.0025	NONE		X		
	6	0.250	NONE			X	
	6	0.250	NONE		X		
	7	0.250	DITHERED ± 3.12 5kHz			X	
	7	0.250	DITHERED ± 3.125 kHz		X		
	8	LDF	NONE			X	
	8	LDF	NONE		X		
	8	HDF	NONE			X	
	8	HDF	NONE		X		
	9	LDF	NONE			X	
	9	LDF	NONE		X		

RX FRQ (MHz)	UWB SIGNAL	PRF (MHz)	UWB MOD	DSL (dBm)	IUPSET (dBm)	REACQ (dBm)	I/S (dB)
	9	**MDF**	**NONE**			X	
	9	**MDF**	**NONE**		X		
	9	**HDF**	**NONE**			X	
	9	**HDF**	**NONE**		X		
	10	**HDF**	**NONE**			X	
	10	**HDF**	**NONE**		X		
	10	**LDF**	**NONE**			X	
	10	**LDF**	**NONE**		X		

5.5 Two Signal Susceptibility - Fixed Frequency – High Level UWB Signal

5.5.1 Two Signal Susceptibility - Fixed Frequency – High Level UWB Signal Test Objective

The objective of this test is to determine the impact of a high level UWB interfering signal on a receiver. The tests will determine the desired signal level that is required for the receiver to operate in a satisfactory manner with a high level UWB interfering signal (e.g., 20 dB above the receiver sensitivity) present.

5.5.2 Two Signal Susceptibility - Fixed Frequency – High Level UWB Signal Test Setup

The test setup is similar to the setup shown in Figure 5. The only differences between this test and the previous test (i.e., the two signal test with the desired signal set at a standard response level) are the levels of the desired and UWB interfering signals.

5.5.3 Two Signal Susceptibility - Fixed Frequency – High Level UWB Signal Test Procedure

The test procedure for determining the desired signal level required for satisfactory operation when a high level interfering signal is present is as follows:

1. Select a UWB waveform from the list presented in Section 4. Adjust the UWB signal so the inband components of the UWB signal are 20 dB above the receiver sensitivity or are at the maximum power available from the pulse generator. Record this level as the ISL in Table 7.

2. Tune the desired signal and the receiver to 112.8 MHz. Inject the desired signal at a level that is below the standard response level. Increase the desired signal level until the receiver achieves a standard response condition. Record the desired and interfering signal levels for the ACQ in Table 7. Record ISL - ACQ as the I/S in Table 7.

3. Decrease the desired signal level until upset occurs. Record this level as SUPSET in Table 7. Record ISL - SUPSET as the I/S in Table 7.

4. Repeat steps 1 through 3 for each of the UWB waveforms listed in Section 4.0.

5. Repeat steps 1 through 4 for each of the test frequencies of 132 MHZ and 151.2 MHz.

5.5.4 Two Signal Susceptibility - Fixed Frequency – High Level UWB Signal Test Output

Record the interfering signal level (ISL) and the desired signal level for the condition where ACQ and SUPSET occurred on the appropriate line on the applicable data sheet provided in Table 7.

TABLE 7. TWO SIGNAL SUSCEPTIBILITY TEST WITH HIGH LEVEL UWB SIGNAL

Receiver: AN/ARC-210 VHF AM Mode
Frequency Band: 108 MHz to 156 MHz
Test Frequencies: 112.8 MHz, 132 MHz, 151.2 MHz
Receiver Mode: Fixed Tuned
Standard Response Criterion: 10 dB SINAD
Desired Signal Modulation: AM
IF Bandwidth: 25 kHz
Sensitivity: - 103 dBm

RX FRQ (MHz)	UWB SIGNAL	PRF (MHz)	UWB MOD	ISL (dBm)	ACQ (dBm)	SUPSET (dBm)	I/S (dB)
112.8	1	56.4	NONE			X	
	1	56.4	NONE		X		
	2	56.4	DITHERED ± 8.75 kHz			X	
	2	56.4	DITHERED ± 8.75 kHz		X		
	3	0.025	DITHERED ± 17.5 kHz			X	
	3	0.025	DITHERED ±		X		

RX FRQ (MHz)	UWB SIGNAL	PRF (MHz)	UWB MOD	ISL (dBm)	ACQ (dBm)	SUPSET (dBm)	I/S (dB)
			17.5 kHz				
	4	0.025	MODULATED			X	
	4	0.025	MODULATED		X		
	5	0.0025	NONE			X	
	5	0.0025	NONE		X		
	6	0.25	NONE			X	
	6	0.25	NONE		X		
	7	0.25	DITHERED ± 4.375 kHz			X	
	7	0.25	DITHERED ± 4.375 kHz		X		
	8	LDF	NONE			X	
	8	LDF	NONE		X		
	8	HDF	NONE			X	
	8	HDF	NONE		X		
	9	LDF	NONE			X	
	9	LDF	NONE		X		
	9	MDF	NONE			X	
	9	MDF	NONE		X		
	9	HDF	NONE			X	
	9	HDF	NONE		X		
	10	HDF	NONE			X	
	10	HDF	NONE		X		
	10	LDF	NONE			X	
	10	LDF	NONE		X		

APPENDIX B
UWB EMI TEST PLAN FOR THE AN/ARC-210 VHF FM MODE

1.0 INTRODUCTION

The AN/ARC-210 very high frequency/ultra high frequency (VHF/UHF) Communication System is a line-of-sight; multi-mode transmitter/receiver system incorporating advanced electromagnetic counter-counter measures (ECCM). The AN/ARC-210 emulates the Single Channel Ground and Airborne Radio System (SINCGARS) in the VHF band (30 MHZ to 88 MHz) and emulates the HAVE QUICK radio in the UHF band (225 MHz to 400 MHz). The AN/ARC-210 uses frequency modulation (FM) in the 30 MHz to 88 MHz band and both amplitude modulation (AM) and FM in the 225 MHz to 400 MHz band. In addition, the radio is capable of providing AM operation in the 108 MHz to 156 MHz band and FM operation in the 156 MHz to 174 MHz band. The nominal sensitivity of the receiver is –103 dBm for AM operation and –108 dBm for FM operation. The system can operate in either fixed frequency or frequency-hopping modes with 25 kHz channel spacing. This test plan is for the AN/ARC-210 operating in the VHF FM Mode in the frequency band from 156 MHz to 174 MHz.

2.0 OVERALL TEST OBJECTIVE

The overall objective of the test is to determine the electromagnetic interference (EMI) susceptibility of the AN/ARC-210 (operating in the VHF FM Mode) to conducted ultra-wideband (UWB) signals that are injected into the receiver antenna port. The results of this investigation will provide the information necessary to evaluate the potential for UWB signals to interfere with the AN/ARC-210 and to understand how UWB systems could be implemented to make use of their unique capabilities without causing EMI.

3.0 TEST APPROACH

In order to accomplish the test objective, there are several parameters that must be measured. These parameters are the sensitivity of the receiver to the desired signal and the susceptibility of the receiver to noise and selected UWB interfering signals. The test will be performed for the receiver operating in both fixed tuned and frequency-hopping modes.

The tests will be performed at the Naval Air Warfare Center Aircraft Division (NAWC AD) Electromagnetic Environmental Effects (E^3) facility by personnel that are familiar with EMI test equipment and are knowledgeable about EMI test procedures and techniques. For the type of scientific testing required for this project, detailed "cookbook" test procedures may be too restrictive and may impede testing. Therefore, detailed test procedures are not considered to be necessary and will not be provided in this test plan. Instead, the plan outlines procedures that will be dynamically adapted during the tests and recorded to ensure consistency and repeatability.

4.0 UWB WAVEFORMS

The UWB waveform parameters that will be used for the AN/ARC-210 receiver shall be selected from the set of waveforms that are presented below. When a filtered baseband pulse waveform is used, the frequency band for the UWB signal shall be selected so the receiver operating band (156 MHz to 174 MHz) falls within the UWB signal band. When the waveform is generated by an unfiltered baseband pulse, the selection of the frequency band does not apply.

The first five waveforms described below should provide the most EMI impact on a receiver. If none of the first five waveforms produce significant EMI impact on the EUT, the impact with other waveforms will be negligible and the testing can end at this point. If any of the first five waveforms result in EMI, additional testing shall be performed using waveforms 6 and 7 to provide a better characterization of the impact.

After completion of testing for the victim specific waveform, each victim will be tested using both of the generic phase shift UWB "Communication" Waveforms, Waveforms 8 and 9, and the generic On-OFF Keying (OOK) UWB "Communication" Waveforms, Waveform 10. These waveforms have been designed to simulate idealized actual UWB communications code schemes and will provide an indication of the EMC of such special codes.

4.1 Test Waveform One (TW1)

For the first test waveform, the pulse repetition frequency (PRF) shall be the maximum value available from the pulse generator that results in the fundamental or a harmonic of the PRF falling within the tuning bandwidth of the receiver.[2] For the AN/ARC-210 operating in the VHF FM Mode, the test frequencies will be 157.8 MHz, 165 MHZ and 172.2 MHZ. The corresponding PRFs for the first test waveform shall be equal to 78.9 MHz, 82.5 MHz and 86.1 MHz respectively. This first test waveform shall not be dithered or modulated. For this case, only one spectral line will fall within the intermediate frequency (IF) passband and the IF signal will appear to be a continuous wave (CW) signal. The receiver shall be tuned to the spectral line.

4.2 Test Waveform Two (TW2)

For the second test waveform, the basic PRF shall be the same as described for the first test waveform. However, the pulses shall be randomly dithered to fill 50% of the IF passband. This will result in a noise like signal in the IF passband and the receiver shall be tuned for maximum impact from the UWB signal.

[2] Note that the reference frequency for the UWB pulse generator is the PRF. Therefore, the terms fundamental and harmonic refer to the fundamental and harmonics of the PRF.

4.3 Test Waveform Three (TW3)

For the third test waveform, the PRF shall be 25 kHz. The pulses shall be dithered randomly to fill 100% of the IF passband. This will result in a noise like signal across the tuning range of the receiver.

4.4 Test Waveform Four (TW4)

For the fourth test waveform, the PRF shall be 25 kHz. The signal shall not be dithered but the **waveform shall be modulated with pulse position modulation (PPM).** This type of UWB interfering signal will result in a modulated signal in the IF passband and the receiver shall be tuned for a maximum impact from the UWB interference.

4.5 Test Waveform Five (TW5)

For the fifth test waveform, the PRF shall be 2.5 kHz. The waveform shall not be modulated or dithered. For this case, the PRF will be slow relative to the IF response time so the individual pulses will appear in the IF (however, the pulse width will be increased and the peak power will be reduced). For this waveform approximately 10 spectral lines will fall within the IF passband.

4.6 Test Waveform Six (TW6)

For the sixth test waveform, the PRF shall be 250 kHz and the pulses shall not be dithered or modulated. For this case, the PRF will be fast relative to the IF response time. Therefore, the signal will appear to be continuous and the effect will be that of a CW signal. Only one spectral line can fall within the IF passband and there should be a spectral line in every tenth channel. To the extent possible the receiver shall be tuned to the spectral line closest to the designated test frequency.

4.7 Test Waveform Seven (TW7)

For the seventh test waveform, the PRF shall be 250 kHz and the pulses shall be dithered randomly to cover 25% of the IF bandwidth. This will result in a noise like signal in the IF passband for every tenth channel and the receiver shall be tuned for a maximum impact from the UWB waveform.

4.8 Test Waveform Eight (TW8)

The eighth test waveform is a stream of doublets with random initial phase orientation. The value of the symbol is determined by the phase relationship of the two pulses in the doublet as shown in Table 1. The two pulses in the doublet are separated by about 1 ns. Doublets themselves have burst repetition interval (BRI) of about 267 ns apart, allowing for a data rate of about 3.75 Mb/s for a high data rate or about 15.625 μs apart, allowing for a data rate of about 64 kb/s for a low data rate. The high data rate timing retains the ratio of peak to average spectral density described in the recent FCC ruling.

Table 1. Pseudorandom Noise Doublet Symbol Mapping

	Data = 0	Data = 1
PN = 0	+ +	+ -
PN = 1	- -	- +

Data is sent in packets of 1200 bits. This includes 1024 of payload data plus 176 bits of header. High data rate packets would be sent at the 3.75 Mp/s rate and last 320 µs. The packets would occur once every 8 ms and the packets would occur once every 8 ms. Low data rate packets would be sent at the 64 kp/s rate and last 18.75 ms and the packet would occur once every 468.75 ms. The payload data would be random, or all ones, or all zeros. The header data would be the same for each packet. Use all ones or all zeros for the header.

4.9 Test Waveform Nine (TW9)

The ninth test waveform is a stream of doublets with fixed initial phase orientation. The value of the symbol is determined by the phase relationship of the two pulses in the doublet as shown in Table 2. The two pulses in the doublet are separated by about 5.708 ns. Doublets themselves have burst repetition interval (BRI) of about 17.123 ns apart, allowing for a data rate of about 58.4 Mb/s. The code has a maximum length 0f 1023 bits. This pulse spacing provides a spectrum with nulls every 175.2 MHz.

Table 2. Constant Phase Doublet Symbol Mapping

DATA	SYMBOL
0	- +
1	+ -

This waveform has three data rates based on the initial 58.4 Mb/s base data rate. The high data rate is simply a continuous stream at this rate. The medium data rate sends a burst of 1023 random symbols with a 175.17 µs BRI for a 10% burst duty factor. The low data rate sends a burst of 1023 random symbols with a 1.7517 ms BRI for a 1% burst duty factor.

4.10 Test Waveform Ten (TW10)

The tenth test waveform is an OOK pattern. Bit spacing is about 5 ns. Every 206 µs a training preamble of constant data rate pulses is sent. There is only one data rate for this waveform.

5.0 RECEIVER SUSCEPTIBILITY TEST

The objective of the receiver susceptibility tests is to obtain data that will provide useful information on the susceptibility of AN/ARC-210 receivers to UWB interference. The tests will be performed using either one or two signals. With the one signal tests, a UWB interfering signal is input to the receiver under test and the output is observed. The receiver is considered to be susceptible if the UWB interfering signal produces a detectable change in the receiver output. No intended in-band signal is used for this test. For the AN/ARC-210, the concern is that EMI may cause changes in the output of the receiver that will impact the desired functionality of the received signal. The changes in the output of the receiver may be manifested as: a change in the output noise; the production of interference at the output; or, activation (of the automatic gain control, etc).

The two signal susceptibility tests described in this test plan require that the receiver desired signal and a UWB interfering signal be simultaneously injected into the receiver antenna port. The concern is that EMI can degrade the performance of the AN/ARC-210. The baseline performance is defined in terms of a standard response that is used to determine receiver sensitivity and provides the basis for the susceptibility tests. For the AN/ARC-210, the standard response is usually defined in terms of a signal to interference, noise, and distortion (SINAD) ratio or a bit error rate (BER). The sensitivity is measured before the susceptibility tests are performed.

There are two approaches that may be used for the two signal susceptibility tests. For the first approach, the desired signal level is fixed at a level that is 6 dB above the standard response level and the receiver susceptibility to UWB interference is determined by slowly increasing the UWB signal strength until the receiver can no longer maintain a standard response. The susceptibility level describes the effect of the UWB interfering signal when the desired signal is close to the standard response level.

For the second approach, a high level UWB interfering signal (e.g., 20 dB above the receiver sensitivity) is injected and the desired signal level that is required for satisfactory operation of the receiver is determined. The information obtained from this test may be used to determine the reduction in range that the receiver will experience as a result of UWB interference. These levels are a better indication of the degradation resulting from UWB interference when the receiver has significant desired signal to operate with and is more typical of normal operations.

5.1 Receiver Sensitivity Measurement – Fixed Frequency Mode

The receiver sensitivity level is specified as the signal level required to create an appropriate standard response that results in satisfactory operation of the receiver. For operation of the AN/ARC-210 in a fixed frequency mode, the standard response is the level that results in a SINAD equal to 10 dB. The receiver sensitivity is measured using an on-tune desired signal that contains the normal receiver modulation.

5.1.1 Receiver Sensitivity Measurement – Fixed Frequency Mode Objective

The objective of this test is to determine the sensitivity of the AN/ARC-210 receiver operating in a fixed frequency mode.

5.1.2 Receiver Sensitivity Measurement – Fixed Frequency Mode Test Set-Up

The test set-up diagram for the receiver sensitivity test is shown in Figure 1.

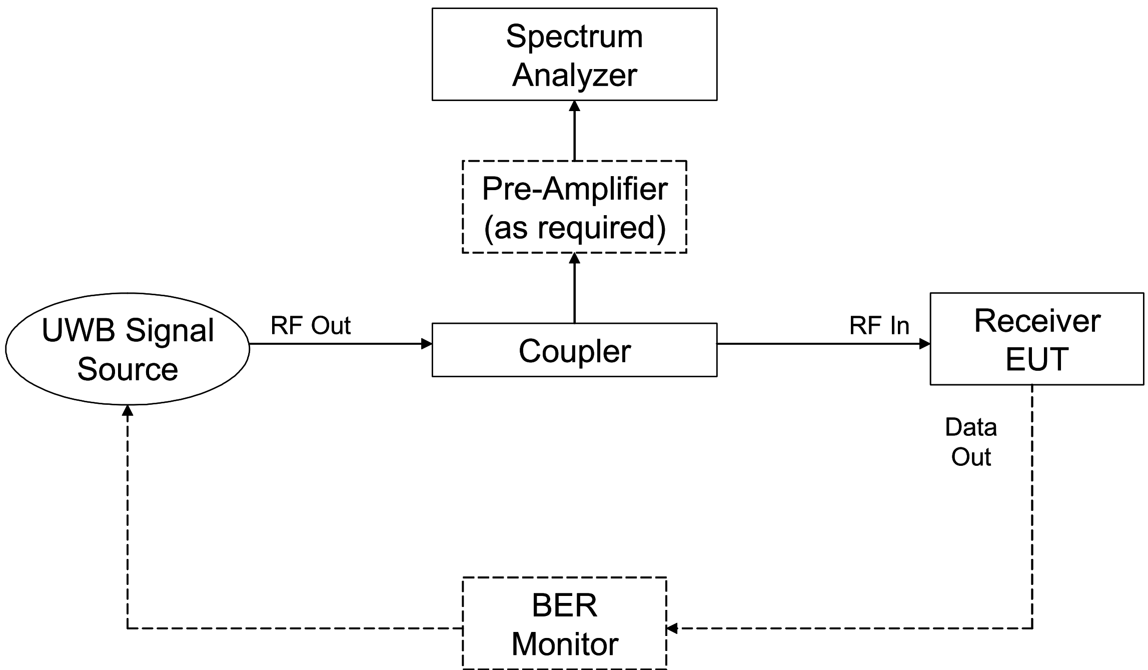

Figure 1. Receiver Sensitivity Test Set-Up

A signal generator or a signal simulator is used to generate the signal used for the test. A spectrum analyzer is used to monitor and measure the signal level at the input to the receiver EUT. A pre-amplifier connected at the input of the spectrum analyzer may be required to observe the signal during the sensitivity test. Alternatively, after the sensitivity level is established, the signal level can be raised by a known, fixed amount (e.g., 40 dB) to enable the spectrum analyzer measurement to be made.

Spectrum analyzer levels shall be corrected for the pre-amplifier gain (if used) plus coupler and/or cable losses that exist in the measurement system. The receiver operation is verified to be satisfactory by monitoring the receiver output and/or measuring the BER of the information data.

5.1.4 Receiver Sensitivity Measurement – Fixed Frequency Mode Test Procedure

The general test procedure for determining receiver sensitivity for operation in a fixed frequency mode is as follows:

7. Tune the receiver to a test frequency. Set the desired signal simulator to the tuned frequency of the receiver and adjust the output power to a level that is at least 10 dB below the receiver nominal sensitivity. The simulator signal shall be modulated in the normal manner used by the receiver and, if appropriate, coded with the receiver's internal code. Verify that the receiver has not achieved a standard response condition for the low level signal.

8. Increase the signal simulator power level until the receiver standard response level is obtained (i.e., 10 dB SINAD). Be sure to pause between each increase in signal power by an amount exceeding the maximum specified settling time for the receiver. Record this as the "standard response acquisition threshold" (ACQ) on the data sheet in Table 3.

9. Increase the input power level an additional 10 dB above the ACQ.

10. Decrease the input power level until the standard response condition is impacted. Record on the data sheet (Table 3) the input power level at which loss of the standard response was first observed. This level is termed the "signal upset threshold" (SUPSET) level. It shall be noted that ACQ and SUPSET may occur at the same level.

11. Steps 1 through 4 shall be performed at frequencies of 157.8 MHz, 165 MHz and 172.2 MHz.

12. If the receiver operates at multiple modes/rates, repeat Steps 1 through 5 while the receiver is operating at several representative modes (e.g., if the receiver operates at several data rates, make the measurements with the receiver operating at minimum, maximum, and nominal data rates).

5.1.4 Receiver Sensitivity Measurement – Fixed Frequency Mode Test Output

The required results from the receiver sensitivity test consist of documenting the ACQ and SUPSET thresholds on the data sheet provided in Table 3. An average threshold value shall be specified if significant differences exist between the thresholds determined in the multiple test trials.

TABLE 3. DATA SHEET FOR SENSITIVITY MEASUREMENTS

Receiver: AN/ARC-210 VHF FM Mode
Frequency Band: 156 MHZ to 174 MHz
Receiver Modes: Fixed tuned
Test Frequencies: 157.8 MHz, 165 MHz, 172.2 MHz
Standard Response Criterion: 10 dB SINAD
Desired Signal Modulation: FM
IF Bandwidth: 25 kHz
Sensitivity: -108 dBm

RCVR FRQ (MHz)	RCVR MODE	ACQ (dBm)	SUPSET (dBm)	NOTES
157.8				
165				
172.2				

NOTE: Sensitivity threshold levels are inherently statistical and thus this procedure shall be conducted multiple times to obtain a representative sample of the threshold level. Tests shall be conducted at frequencies corresponding to 10%, 50% and 90% of the tuning band.

5.2 White Noise Test Method

The white noise susceptibility test method is performed by injecting a desired signal and a white noise signal, with the same or greater bandwidth as that of the victim receiver, directly into the receive antenna port and observing the impact at the output of the receiver.

5.2.1 White Noise Test Objective

The objective of this test is to determine the impact of white noise signals on a receiver and determine the susceptibility threshold as a function of the white noise signal parameters.

5.2.2 White Noise Test Setup

The test setup is shown in Figure 2.

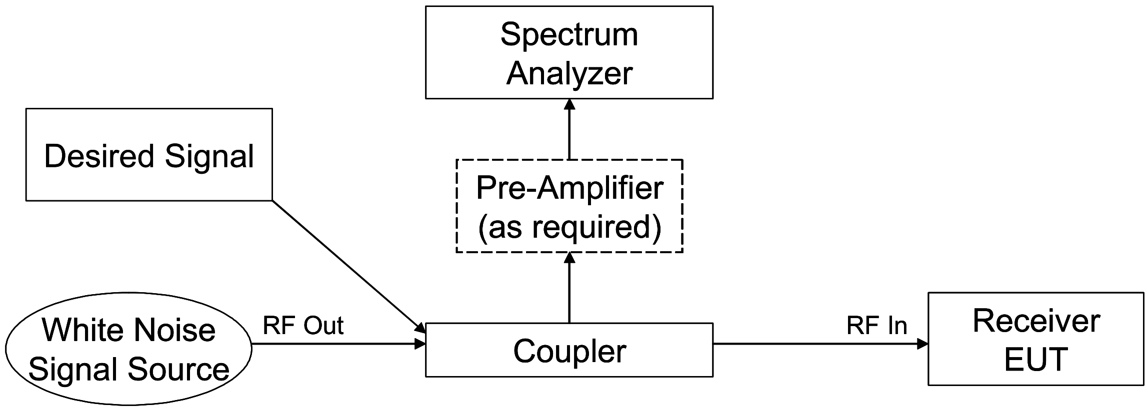

Figure 2. Set-Up for White Noise Susceptibility Test

5.2.3 White Noise Test Procedure

5. Set up AN/ARC-210 for fixed frequency operation in the VHF band.

6. Input the desired signal at a frequency of 157.8 MHz and at the standard response level.

7. Inject the white noise signal into the receiver input at a level that is at least 10 dB above the receiver standard response level. The noise level shall be high enough to mask the desired signal at the receiver output. The average noise level shall be measured using the spectrum analyzer with a resolution bandwidth of 1 kHz, 30 kHz or 1 MHz (or similar bandwidths). The bandwidth shall be selected so it is the highest of the three choices that is less than the receiver IF bandwidth. Empirical or calculated bandwidth correction factors shall be used to adjust the readings to the IF bandwidth of the receiver. Increase the desired signal level to obtain a standard response condition. Record the desired and noise interfering signal levels on the data sheet in Table 4.

8. Repeat steps 1 through 3 at frequencies of 165 MHz and 172.2 MHz.

5.2.4 White Noise Test Output

The test output will define white noise waveform conditions that result in EMI.

TABLE 4. DATA SHEET FOR WHITE NOISE TESTS

Receiver: AN/ARC-210 VHF FM Mode
Frequency Band: 156 MHz to 174 MHz
Receiver Mode: Fixed Tuned,
Test Frequencies: 157.8 MHz, 165 MHz, 172.2
Standard Response Criterion: 10 dB SINAD
Desired Signal Modulation: FM
IF Bandwidth: 25 kHz
Sensitivity: -108 dBm

	SIGNAL LEVEL (dBm)	**NOISE LEVEL (dBm)**
STANDARD RESPONSE LEVEL		**N/A**
LEVEL WHERE NOISE MASKS SIGNAL		
STANDARD RESPONSE LEVEL WITH NOISE		

5.3 One Signal Susceptibility Test Method

The one signal susceptibility test method is performed by injecting a UWB signal, with the appropriate waveform parameters as defined in Section 4.0, directly into the receive antenna port and observing the impact at the output of the receiver. If the receiver exhibits a change in the output as a result of the injected interfering signal, the receiver is considered to be susceptible. The change in the output may be manifested as a change in the output noise, the production of an interfering signal at the receiver output, activation of the receiver automatic gain control, etc.

5.3.1 One Signal Susceptibility Test Objective

The objective of this test is to determine the impact of UWB signals on a receiver and determine the susceptibility threshold as a function of the UWB signal parameters.

5.3.2 One Signal Susceptibility Test Setup

The test setup is shown in Figure 3.

5.3.3 One Signal Susceptibility Test Procedure

The procedure is to inject a UWB signal into the receiver input and observe the receiver output for any change that may provide an indication of susceptibility. Examples of indications of susceptibility are changes in the output noise, the production of an interfering signal at the output, activation of the receiver automatic gain control, etc. The tests shall be conducted for each of the applicable UWB waveforms identified in Section 4.0 and at each of the frequencies specified in Section 5.3. The UWB interference upset

(IUPSET) conditions that provided an indication of susceptibility shall be recorded in Table 5.

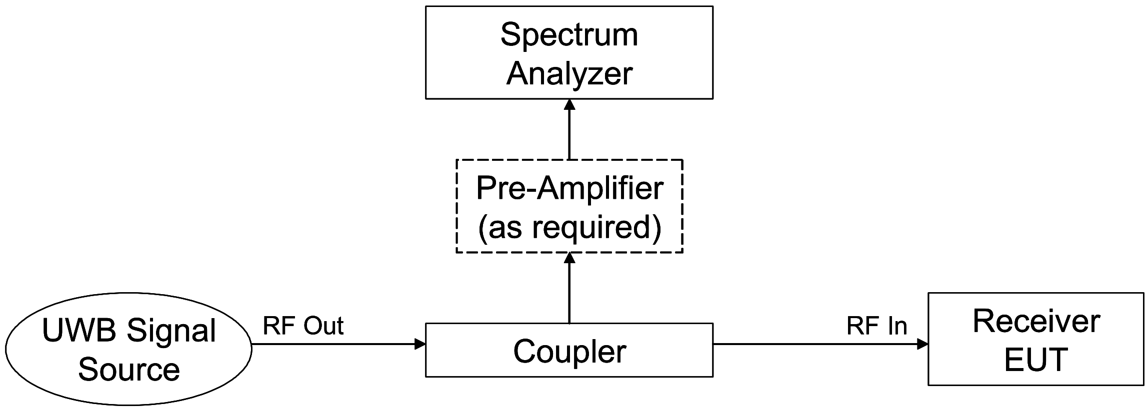

Figure 3. Setup For One Signal Susceptibility Test

Table 5. DATA SHEET FOR ONE SIGNAL SUSCEPTIBILITY TEST

Receiver: AN/ARC-210 VHF FM Mode
Frequency Band: 156 to 174 MHz
Receiver Mode: Fixed Tuned
Test Frequencies: 157.8 MHz, 165 MHz, 172.2. MHz
Standard Response Criterion: 10 dB SINAD
Desired Signal Modulation: FM
IF Bandwidth: 25 kHz
Sensitivity: -108 dBm

RX FRQ (MHz)	UWB SIGNAL	PRF (MHz)	UWB MOD	IUPSET (dBm)
112.8	1	56.4	NONE	
	2	56.4	DITHERED ± 8.75 kHz	
	3	0.025	DITHERED ± 17.5 kHz	
	4	0.025	OOK	
	5	0.0025	NONE	
	6	0.250	NONE	
	7	0.250	DITHERED ± 4.375 kHz	
	8	Low Duty Factor (LDF)	NONE	

	8	**High Duty Factor (HDF)**	**NONE**	
	9	**LDF**	**NONE**	
	9	**Medium Duty Factor (MDF)**	**NONE**	
	9	**HDF**	**NONE**	
	10	**LDF**	**NONE**	
	10	**HDF**	**NONE**	

Note that the spectrum analyzer resolution and video bandwidths will not be as wide as the RF bandwidth of the UWB waveform. The resolution bandwidth (RBW) of the spectrum analyzer shall be 30 kHz or the spectrum analyzer RBW closest to, but not exceeding, 35 kHz. The spectrum analyzer video bandwidth (VBW) shall be equal to or greater than the RBW. Empirical or calculated bandwidth correction factors shall be used to adjust the measurement of the UWB waveform to the IF bandwidth of the receiver. Average measurements shall be made for all of the test waveforms except for Waveform Five which shall be made as a peak measurement. Record the interfering signal conditions (signal parameters and levels) that cause an impact on the receiver output.

5.3.4 One Signal Susceptibility Test Output

The test output will define UWB waveform conditions that result in EMI.

5.4 Two Signal Susceptibility Test - Fixed Frequency – Standard Response Desired Signal

5.4.1 Two Signal Susceptibility Test - Fixed Frequency – Standard Response Desired Signal Test Objective

The objective of this EMI test is to determine the susceptibility of an AN/ARC-210 receiver to UWB interfering signals. Susceptibility thresholds will be determined by monitoring the output of the receiver and/or measuring the BER for the information data.

5.4.2 Two Signal Susceptibility Test - Fixed Frequency – Standard Response Desired Signal Test Setup

The test setup is shown in Figure 4.

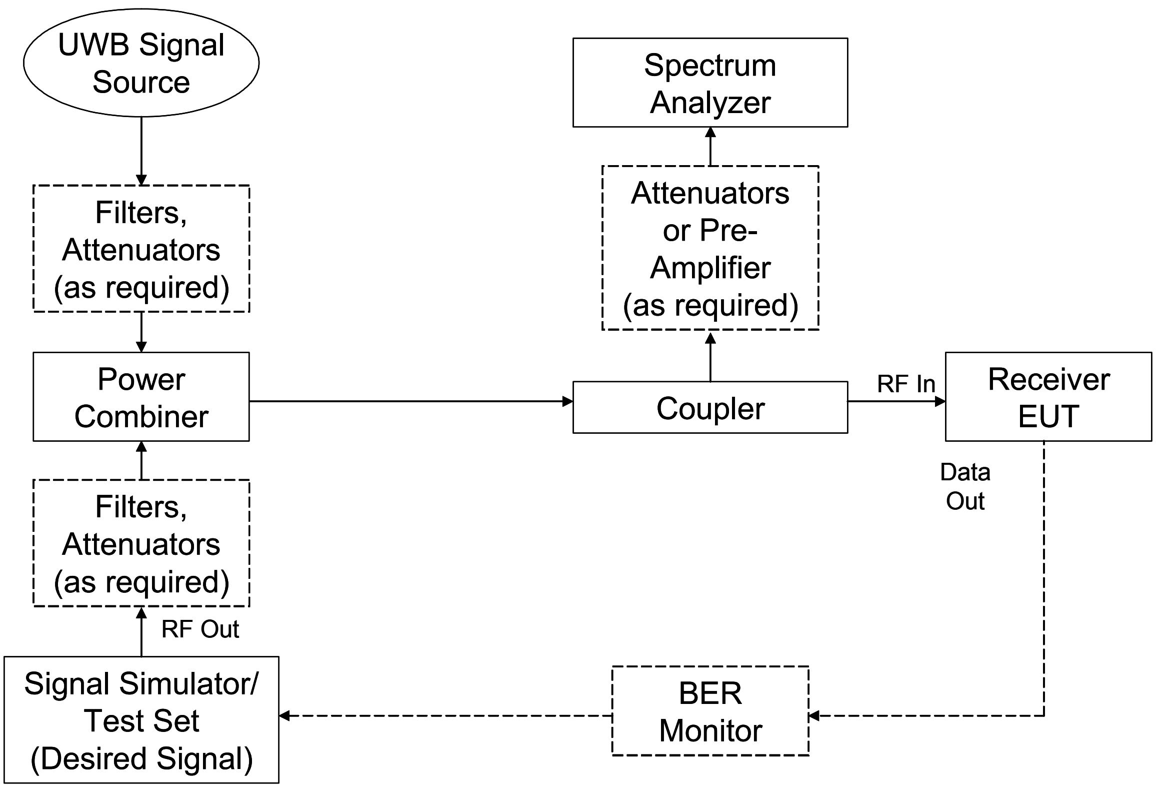

Figure 4. Conducted Susceptibility Test Set-Up-Two Signal Method

5.4.3 Two Signal Susceptibility Test - Fixed Frequency – Standard Response Desired Signal Test Procedure

The two signal susceptibility test procedure should define the performance impact that a receiver will sustain as a result of EMI from a UWB signal. In order to obtain meaningful results, it is necessary to use a desired signal level that is sufficiently above the receiver noise level to minimize the impact of receiver noise on performance.

The receiver standard response level is often defined in terms of the signal level required to produce a SINAD equal to 10 dB at the output of the receiver. If there is no interference or distortion, the 10 dB SINAD translates to a 10 dB signal-to-noise ratio. If a noise like interfering signal at the receiver noise level is added to the receiver input, the SINAD would decrease by 3 dB (i.e. from 10 dB to 7 dB). This is too close to the receiver noise and the test results may be affected by the receiver noise as well as by the UWB interference. If the desired signal is 10 dB above the receiver noise, a noise like

EMI signal at the noise level would have little impact on performance. As a result of the factors discussed , it was decided that a desired signal level that is 6 dB above the standard response level should be used for testing.

The general test procedure for determining receiver susceptibility to interference when the desired signal is 6 dB above the standard response level and the receiver is operating at a fixed frequency is as follows:

8. Tune the receiver to a test frequency of 157.8 MHz. Set the desired signal to the test frequency. Adjust the desired signal to a level that is 6 dB above the ACQ as measured in Section 5.2. Verify that the receiver output exceeds a standard response condition (i.e., SINAD is greater than 10 dB).

9. Decrease the desired signal until the level is 6 dB above the SUPSET. Record this level in Table 6 as the "desired signal level" (DSL) for the selected UWB waveform used for the tests. Verify that the receiver output exceeds the standard response condition.

10. Activate the UWB interference signal source with one of the UWB test waveforms at a level that is 20 dB below the SUPSET level recorded in Section 5.2.

11. Increase the interference signal power level until there is an indication of impact on the receiver standard response condition (i.e., a decrease in the SINAD). Record this level as the UPSET level in Table 6. Record IUPSET – DSL as the interference-to-signal ratio (I/S).

12. Set the desired signal level to 6 dB above the acquisition threshold level. Record this level as the DSL on the second row for the selected UWB waveform. Set the UWB interfering signal to the maximum level available. Decrease the UWB interference signal power until the receiver returns to a standard response condition and all parameters are within acceptable limits. Record this interference level in Table 6 as the "interfering signal reacquisition threshold" (REACQ) level. Record REACQ – DSL as the I/S ratio.

13. Repeat Steps 1 through 5 for each of the UWB test waveforms.

14. Repeat Steps 1 through 6 for receiver operating frequencies of 165 MHZ and 172.2 MHz.

5.4.4 Two Signal Susceptibility Test - Fixed Frequency – Standard Response Desired Signal Test Output

The required results from the two signal EMI tests consist of recording the desired signal level (DSL), the interfering signal level for the IUPSET and REACQ and the I/S ratio on the appropriate line on the applicable data sheet for the UWB interference signal modulations and receiver modes of operation.

Table 6. TWO SIGNAL SUSCEPTIBILITY TEST WITH DESIRED SIGNAL AT STANDARD RESPONSE LEVEL

Receiver: AN/ARC-210 VHF FM Mode
Frequency Band: 156 MHz to 174 MHz
Test Frequencies: 157.8 MHz, 165 MHz, 172.2 MHz
Receiver Mode: Fixed Tuned
Standard Response Criterion: 10 dB SINAD
Desired Signal Modulation: FM
IF Bandwidth: 25 kHz
Sensitivity: - 108 dBm

RX FRQ (MHz)	UWB SIGNAL	PRF (MHz)	UWB MOD	DSL (dBm)	IUPSET (dBm)	REACQ (dBm)	I/S (dB)
157.8	1	78.9	NONE			X	
	1	78.9	NONE		X		
	2	78.9	DITHERED ± 6.25 kHz			X	
	2	78.9	DITHERED ± 6.25 kHz		X		
	3	0.025	DITHERED ± 12.5 kHz			X	
	3	0.025	DITHERED ± 12.5 kHz		X		
	4	0.025	MODULATED			X	
	4	0.025	MODULATED		X		
	5	0.0025	NONE			X	
	5	0.0025	NONE		X		
	6	0.250	NONE			X	
	6	0.250	NONE		X		
	7	0.250	DITHERED ± 3.12 5kHz			X	
	7	0.250	DITHERED ± 3.125 kHz		X		
	8	LDF	NONE			X	
	8	LDF	NONE		X		
	8	HDF	NONE			X	
	8	HDF	NONE		X		
	9	LDF	NONE			X	
	9	LDF	NONE		X		
	9	MDF	NONE			X	
	9	MDF	NONE		X		

RX FRQ (MHz)	UWB SIGNAL	PRF (MHz)	UWB MOD	DSL (dBm)	IUPSET (dBm)	REACQ (dBm)	I/S (dB)
	9	HDF	NONE			X	
	9	HDF	NONE		X		
	10	HDF	NONE			X	
	10	HDF	NONE		X		
	10	LDF	NONE			X	
	10	LDF	NONE		X		

5.5 Two Signal Susceptibility - Fixed Frequency – High Level UWB Signal

5.5.1 Two Signal Susceptibility - Fixed Frequency – High Level UWB Signal Test Objective

The objective of this test is to determine the impact of a high level UWB interfering signal on a receiver. The tests will determine the desired signal level that is required for the receiver to operate in a satisfactory manner with a high level UWB interfering signal (e.g., 20 dB above the receiver sensitivity) present.

5.5.2 Two Signal Susceptibility - Fixed Frequency – High Level UWB Signal Test Setup

The test setup is similar to the setup shown in Figure 5. The only differences between this test and the previous test (i.e., the two signal test with the desired signal set at a standard response level) are the levels of the desired and UWB interfering signals.

5.5.3 Two Signal Susceptibility - Fixed Frequency – High Level UWB Signal Test Procedure

The test procedure for determining the desired signal level required for satisfactory operation when a high level interfering signal is present is as follows:

6. Select a UWB waveform from the list presented in Section 4. Adjust the UWB signal so the inband components of the UWB signal are 20 dB above the receiver sensitivity or are at the maximum power available from the pulse generator. Record this level as the ISL in Table 7

7. Tune the desired signal and the receiver to 157.8 MHz. Inject the desired signal at a level that is below the standard response level. Increase the desired signal level until the receiver achieves a standard response condition. Record the desired and interfering signal levels for the ACQ in Table 7. Record ISL - ACQ as the I/S in Table 7.

8. Decrease the desired signal level until upset occurs. Record this level as SUPSET in Table 7. Record ISL - SUPSET as the I/S in Table 7.

9. Repeat steps 1 through 3 for each of the UWB waveforms listed in Section 4.0.

10. Repeat steps 1 through 4 for each of the test frequencies of 165 MHZ and 172.2 MHz.

5.5.4 Two Signal Susceptibility - Fixed Frequency – High Level UWB Signal Test Output

Record the interfering signal level (ISL) and the desired signal level for the condition where ACQ and SUPSET occurred on the appropriate line on the applicable data sheet provided in Table 7.

Table 7. TWO SIGNAL SUSCEPTIBILITY TEST WITH HIGH LEVEL UWB SIGNAL

Receiver: AN/ARC-210 VHF FM Mode
Frequency Band: 156 MHz to 174 MHz
Test Frequencies: 157.8 MHz, 165 MHz, 172.2 MHz
Receiver Mode: Fixed Tuned
Standard Response Criterion: 10 dB SINAD
Desired Signal Modulation: FM
IF Bandwidth: 25 kHz
Sensitivity: - 108 dBm

RX FRQ (MHz)	UWB SIGNAL	PRF (MHz)	UWB MOD	ISL (dBm)	ACQ (dBm)	SUPSET (dBm)	I/S (dB)
157.8	1	78.9	NONE			X	
	1	78.9	NONE		X		
	2	78.9	DITHERED ± 8.75 kHz			X	
	2	78.9	DITHERED ± 8.75 kHz		X		
	3	0.025	DITHERED ± 17.5 kHz			X	
	3	0.025	DITHERED ± 17.5 kHz		X		
	4	0.025	MODULATED			X	
	4	0.025	MODULATED		X		
	5	0.0025	NONE			X	
	5	0.0025	NONE		X		
	6	0.25	NONE			X	
	6	0.25	NONE		X		

RX FRQ (MHz)	UWB SIGNAL	PRF (MHz)	UWB MOD	ISL (dBm)	ACQ (dBm)	SUPSET (dBm)	I/S (dB)
	7	0.25	DITHERED ± 4.375 kHz			X	
	7	0.25	DITHERED ± 4.375 kHz		X		
	8	LDF	NONE			X	
	8	LDF	NONE		X		
	8	HDF	NONE			X	
	8	HDF	NONE		X		
	9	LDF	NONE			X	
	9	LDF	NONE		X		
	9	MDF	NONE			X	
	9	MDF	NONE		X		
	9	HDF	NONE			X	
	9	HDF	NONE		X		
	10	HDF	NONE			X	
	10	HDF	NONE		X		
	10	LDF	NONE			X	
	10	LDF	NONE		X		

APPENDIX C
UWB EMI TEST PLAN FOR AN/ARC-210 UHF HAVE QUICK MODE

1.0 INTRODUCTION

The AN/ARC-210 very high frequency/ultra high frequency (VHF/UHF) Communication System is a line-of-sight; multi-mode transmitter/receiver system incorporating advanced electromagnetic counter-counter measures (ECCM) techniques. The AN/ARC-210 emulates the Single Channel Ground and Airborne Radio System (SINCGARS) in the VHF band (30 MHZ to 88 MHz) and emulates the HAVE QUICK radio in the UHF band (225 MHz to 400 MHz). The AN/ARC-210 uses frequency modulation (FM) in the 30 MHz to 88 MHz band and both amplitude modulation (AM) and FM in the 225 MHz to 400 MHz band. In addition, the radio is capable of providing AM operation in the 108 MHz to 156 MHz band and FM operation in the 156 MHz to 174 MHz band. The nominal sensitivity of the receiver is –103 dBm for AM and –108 dBm for FM operation. The system can operate in either fixed frequency or frequency-hopping modes with a channel spacing of 25 kHz. This test plan is for the AN/ARC-210 operating in the UHF HAVE QUICK mode.

2.0 OVERALL TEST OBJECTIVE

The overall objective of the test is to determine the electromagnetic interference (EMI) susceptibility of the AN/ARC-210 to conducted ultra-wideband (UWB) signals that are injected into the receiver antenna port. The results of this investigation will provide the information necessary to evaluate the potential for UWB signals to interfere with the AN/ARC-210 and to understand how UWB systems could be implemented to make use of their unique capabilities without causing EMI.

3.0 TEST APPROACH

In order to accomplish the test objective, there are several parameters that must be measured. These parameters are the sensitivity of the receiver to the desired signal and the susceptibility of the receiver to noise and selected UWB interfering signals. The test will be performed for the receiver operating in both fixed tuned and frequency-hopping modes.

The tests will be performed at the Naval Air Warfare Center Aircraft Division (NAWC AD) Electromagnetic Environmental Effects (E^3) facility by personnel that are familiar with EMI test equipment and are knowledgeable about EMI test procedures and techniques. For the type of scientific testing required for this project, detailed "cookbook" test procedures may be too restrictive and may impede testing. Therefore, detailed test procedures are not considered to be necessary and will not be provided in this test plan. Instead, the plan outlines procedures that will be dynamically adapted during the tests and recorded to ensure consistency and repeatability.

4.0 UWB WAVEFORMS

The UWB waveform parameters that will be used for the AN/ARC-210 receiver shall be selected from the set of waveforms that are presented below. When a filtered baseband pulse waveform is used, the frequency band for the UWB signal shall be selected so the receiver operating band (225 MHz to 400 MHz) falls within the UWB signal band. When the waveform is generated by an unfiltered baseband pulse, the selection of the frequency band does not apply.

The first five waveforms described below should provide the most EMI impact on a receiver. If none of the first five waveforms produce significant EMI impact on the EUT, the impact with other waveforms will be negligible and the testing can end at this point. If any of the first five waveforms result in EMI, additional testing shall be performed using waveforms 6 and 7 to provide a better characterization of the impact.

After completion of testing for the victim specific waveform, each victim will be tested using both of the generic phase shift UWB “Communication” Waveforms, Waveforms 8 and 9, and the generic On-OFF Keying (OOK) UWB “Communication” Waveforms, Waveform 10. These waveforms have been designed to simulate idealized actual UWB communications code schemes and will provide an indication of the EMC of such special codes.

4.1 Test Waveform One (TW1)

For the first test waveform, the pulse repetition frequency (PRF) shall be the maximum value available from the pulse generator that results in the fundamental or a harmonic of the PRF falling within the tuning range of the receiver.[3] For the AN/ARC-210 operating in the UHF frequency band, the test frequencies will be 242.5 MHz, 312.5 MHZ and 382.5 MHZ. The corresponding PRFs for the first test waveform shall be 80.833 MHz, 78.125 MHz and 95.625 MHz. This first test waveform shall not be dithered or modulated. For this case, only one spectral line will fall within the intermediate frequency (IF) passband and the IF signal will appear to be a continuous wave (CW) signal. The receiver shall be tuned to the spectral line.

4.2 Test Waveform Two (TW2)

For the second test waveform, the basic PRF shall be the same as described for the first test waveform. However, the pulses shall be randomly dithered to fill 50% of the IF passband. This will result in a noise like signal in the IF passband and the receiver shall be tuned for maximum impact from the UWB signal.

[3] Note that the reference frequency for the UWB pulse generator is the PRF. Therefore, the terms fundamental and harmonic refer to the fundamental and harmonics of the PRF.

4.3 Test Waveform Three (TW3)

For the third test waveform, the PRF shall be 25 kHz. The pulses shall be dithered randomly to fill 100% of the IF passband. This will result in a noise like signal across the tuning range of the receiver.

4.4 Test Waveform Four (TW4)

For the fourth test waveform, the PRF shall be 25 kHz. The signal shall not be dithered but the waveform shall be modulated with on-off keying (OOK). This type of UWB interfering signal will result in a modulated signal in the IF passband and the receiver shall be tuned for a maximum impact from the UWB interference.

4.5 Test Waveform Five (TW5)

For the fifth test waveform, the PRF shall be 2.5 kHz. The waveform shall not be modulated or dithered. For this case, the PRF will be slow relative to the IF response time so the individual pulses will appear in the IF (however, the pulse width will be increased and the peak power will be reduced). For this waveform approximately 10 spectral lines will fall within the IF passband.

4.6 Test Waveform Six (TW6)

For the sixth test waveform, the PRF shall be 250 kHz and the pulses shall not be dithered or modulated. For this case, the PRF will be fast relative to the IF response time. Therefore, the signal will appear to be continuous and the effect will be that of a CW signal. Only one spectral line can fall within the IF passband and to the extent possible the receiver shall be tuned to the spectral line closest to the designated test frequency .

4.7 Test Waveform Seven (TW7)

For the seventh test waveform, the PRF shall be 250 kHz and the pulses shall be dithered randomly to cover 25% of the IF bandwidth. This will result in a noise like signal in the IF passband and the receiver shall be tuned for a maximum impact from the UWB waveform.

4.8 Test Waveform Eight (TW8)

The eighth test waveform is a stream of doublets with random initial phase orientation. The value of the symbol is determined by the phase relationship of the two pulses in the doublet as shown in Table 1. The two pulses in the doublet are separated by about 1 ns. Doublets themselves have burst repetition interval (BRI) of about 267 ns apart, allowing for a data rate of about 3.75 Mb/s for a high data rate or about 15.625 μs apart, allowing for a data rate of about 64 kb/s for a low data rate. The high data rate timing retains the ratio of peak to average spectral density described in the recent FCC ruling.

Table 1. Pseudorandom Noise Doublet Symbol Mapping

	Data = 0	Data = 1
PN = 0	+ +	+ -
PN = 1	- -	- +

Data is sent in packets of 1200 bits. This includes 1024 of payload data plus 176 bits of header. High data rate packets would be sent at the 3.75 Mp/s rate and last 320 μs. The packets would occur once every 8 ms and the packets would occur once every 8 ms. Low data rate packets would be sent at the 64 kp/s rate and last 18.75 ms and the packet would occur once every 468.75 ms. The payload data would be random, or all ones, or all zeros. The header data would be the same for each packet. Use all ones or all zeros for the header.

4.9 Test Waveform Nine (TW9)

The ninth test waveform is a stream of doublets with fixed initial phase orientation. The value of the symbol is determined by the phase relationship of the two pulses in the doublet as shown in Table 2. The two pulses in the doublet are separated by about 5.708 ns. Doublets themselves have burst repetition interval (BRI) of about 17.123 ns apart, allowing for a data rate of about 58.4 Mb/s. The code has a maximum length 0f 1023 bits. This pulse spacing provides a spectrum with nulls every 175.2 MHz.

Table 2. Constant Phase Doublet Symbol Mapping

DATA	SYMBOL
0	- +
1	+ -

This waveform has three data rates based on the initial 58.4 Mb/s base data rate. The high data rate is simply a continuous stream at this rate. The medium data rate sends a burst of 1023 random symbols with a 175.17 μs BRI for a 10% burst duty factor. The low data rate sends a burst of 1023 random symbols with a 1.7517 ms BRI for a 1% burst duty factor.

4.10 Test Waveform Ten (TW10)

The tenth test waveform is an OOK pattern. Bit spacing is about 5 ns. Every 206 μs a training preamble of constant data rate pulses is sent. There is only one data rate for this waveform.

5.0 RECEIVER SUSCEPTIBILITY TEST

The objective of the receiver susceptibility tests is to obtain data that will provide useful information on the susceptibility of AN/ARC-210 receivers to UWB interference. The tests will be performed using either one or two signals. With the one signal tests, a UWB interfering signal is input to the receiver under test and the output is observed. The receiver is considered to be susceptible if the UWB interfering signal produces a detectable change in the receiver output. No intended in-band signal is used for this test. For the AN/ARC-210, the concern is that EMI may cause changes in the output of the receiver that will impact the desired functionality of the received signal. The changes in the output of the receiver may be manifested as: a change in the output noise; the production of interference at the output; or, activation (of the automatic gain control, etc).

The two signal susceptibility tests described in this test plan require that the receiver desired signal and a UWB interfering signal be simultaneously injected into the receiver antenna port. The concern is that EMI can degrade the performance of the AN/ARC-210. The baseline performance is defined in terms of a standard response that is used to determine receiver sensitivity and provides the basis for the susceptibility tests. For the AN/ARC-210, the standard response is usually defined in terms of a signal to interference, noise, and distortion (SINAD) ratio or a bit error rate (BER). The sensitivity is measured before the susceptibility tests are performed.

There are two approaches that may be used for the two signal susceptibility tests. For the first approach, the desired signal level is fixed at a level that is 6 dB above the standard response level and the receiver susceptibility to UWB interference is determined by slowly increasing the UWB signal strength until the receiver can no longer maintain a standard response. The susceptibility level describes the effect of the UWB interfering signal when the desired signal is close to the standard response level.

For the second approach, a high level UWB interfering signal (e.g., 20 dB above the receiver sensitivity) is injected and the desired signal level that is required for satisfactory operation of the receiver is determined. The information obtained from this test may be used to determine the reduction in range that the receiver will experience as a result of UWB interference. These levels are a better indication of the degradation resulting from UWB interference when the receiver has significant desired signal to operate with and is more typical of normal operations.

5.1 Receiver Sensitivity Measurement – Fixed Frequency Mode

The receiver sensitivity level is specified as the signal level required to create an appropriate standard response that results in satisfactory operation of the receiver. For operation of the AN/ARC-210 in a fixed frequency mode, the standard response is the level that results in a SINAD equal to 10 dB. The receiver sensitivity is measured using an on-tune desired signal that contains the normal receiver modulation.

5.1.1 Receiver Sensitivity Measurement – Fixed Frequency Mode Objective

The objective of this test is to determine the sensitivity of the AN/ARC-210 receiver operating in a fixed frequency mode.

5.1.2 Receiver Sensitivity Measurement – Fixed Frequency Mode Test Set-Up

The test set-up diagram for the receiver sensitivity test is shown in Figure 1.

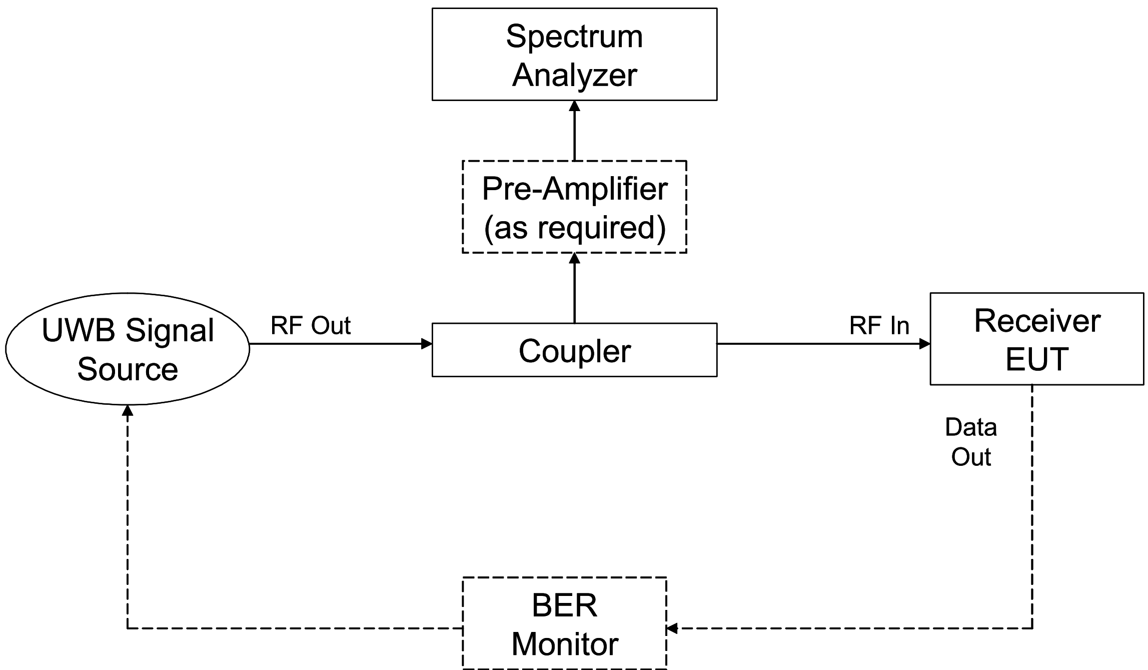

Figure 1. Receiver Sensitivity Test Set-Up

A signal generator or a signal simulator is used to generate the signal used for the test. A spectrum analyzer is used to monitor and measure the signal level at the input to the receiver EUT. A pre-amplifier connected at the input of the spectrum analyzer may be required to observe the signal during the sensitivity test. Alternatively, after the sensitivity level is established, the signal level can be raised by a known, fixed amount (e.g., 40 dB) to enable the spectrum analyzer measurement to be made.

Spectrum analyzer levels shall be corrected for the pre-amplifier gain (if used) plus coupler and/or cable losses that exist in the measurement system. The receiver operation is verified to be satisfactory by monitoring the receiver output and/or measuring the BER of the information data.

5.1.5 Receiver Sensitivity Measurement – Fixed Frequency Mode Test Procedure

The general test procedure for determining receiver sensitivity for operation in a fixed frequency mode is as follows:

13. Tune the receiver to a test frequency. Set the desired signal simulator to the tuned frequency of the receiver and adjust the output power to a level that is at least 10 dB below the receiver nominal sensitivity. The simulator signal shall be modulated in the normal manner used by the receiver and, if appropriate, coded with the receiver's internal code. Verify that the receiver has not achieved a standard response condition for the low level signal.

14. Increase the signal simulator power level until the receiver standard response level is obtained (i.e., 10 dB SINAD). Be sure to pause between each increase in signal power by an amount exceeding the maximum specified settling time for the receiver. Record this as the "standard response acquisition threshold" (ACQ) on the data sheet in Table 3.

15. Increase the input power level an additional 10 dB above the ACQ.

16. Decrease the input power level until the standard response condition is impacted. Record on the data sheet (Table 3) the input power level at which loss of the standard response was first observed. This level is termed the "signal upset threshold" (SUPSET) level. It shall be noted that ACQ and SUPSET may occur at the same level.

17. Steps 1 through 4 shall be performed at frequencies of 242.5 MHz, 312.5 MHz and 382.5 MHz.

18. If the receiver operates at multiple modes/rates, repeat Steps 1 through 5 while the receiver is operating at several representative modes (e.g., if the receiver operates at several data rates, make the measurements with the receiver operating at minimum, maximum, and nominal data rates).

5.1.4 Receiver Sensitivity Measurement – Fixed Frequency Mode Test Output

The required results from the receiver sensitivity test consist of documenting the ACQ and SUPSET thresholds on the data sheet provided in Table 3. An average threshold value shall be specified if significant differences exist between the thresholds determined in the multiple test trials.

Table 3. DATA SHEET FOR SENSITIVITY MEASUREMENTS

Receiver: AN/ARC-210 UHF HAVE QUICK Mode
Frequency Band: 225 MHZ to 400 MHz
Receiver Modes: Frequency Hopping
Test Frequencies: 242.5 MHz, 312.5 MHz, 382.5 MHz
Standard Response Criterion: 10 dB SINAD
Desired Signal Modulation: AM
IF Bandwidth: 25 kHz
Sensitivity: -103 dBm

RCVR FRQ (MHz)	RCVR MODE	ACQ (dBm)	SUPSET (dBm)	NOTES

NOTE: Sensitivity threshold levels are inherently statistical and thus this procedure shall be conducted multiple times to obtain a representative sample of the threshold level. Tests shall be conducted at frequencies corresponding to 10%, 50% and 90% of the tuning band.

5.2 Receiver Sensitivity Measurement – Frequency - Hopping Mode

When the receiver is operating in a frequency-hopping mode, the receiver must acquire and maintain synchronization to operate properly. For the frequency-hopping mode of operation, the receiver sensitivity may be defined in terms of the ACQ, which is the signal level required for the receiver to acquire synchronization and achieve an acceptable BER, and the SUPSET, which is the signal level required for the receiver to maintain an acceptable BER once acquisition has occurred.

5.2.1 Receiver Sensitivity Measurement – Frequency - Hopping Mode Objective

The objective of this test is to measure the ACQ and SUPSET thresholds for the AN/ARC-210 receiver operating in a frequency-hopping mode..

5.2.2 Receiver Sensitivity Measurement – Frequency - Hopping Mode Test Setup

The test setup is shown in Figure 1.

5.2.3 Receiver Sensitivity Measurement – Frequency - Hopping Mode Test Procedures

The general test procedure for determining receiver sensitivity for a frequency-hopping mode is as follows:

1. Set the signal simulator (or transmitter) and the receiver to operate with the same hopset. Adjust the output level for the desired signal simulator so it is at least 10 dB below the nominal receiver sensitivity. The simulated signal shall be modulated in the normal manner used by the receiver and, if appropriate, coded with the receiver's internal code. Verify that the receiver has not acquired synchronization with the low level signal.

2. Increase the signal simulator power level until the receiver acquires synchronization and is operating at a standard response level (e.g., a 10% BER). Be sure to pause between each increase in signal power by an amount exceeding the maximum specified settling time for the receiver. Record the input power level at which the standard response condition was acquired. This power level which is defined as the ACQ shall be recorded in Table 3.

3. Increase the input power level an additional 10 dB above the ACQ.

4. Decrease the input power level until the BER drops below an acceptable level. Record in Table 3 the input power level at which the unacceptable BER was first observed. This level is termed the SUPSET level.

NOTE: Sensitivity threshold levels are inherently statistical and thus multiple trials of this procedure, using different hopsets, shall be conducted to obtain a representative sample of the threshold level.

5.2.4 Receiver Sensitivity Measurement – Frequency - Hopping Mode Test Output

The required results from the receiver sensitivity test consist of recording the ACQ and the SUPSET on the data sheet provided in Table 3. An average threshold value shall be specified if significant differences exist between the thresholds determined in the multiple test trials.

5.3 White Noise Test Method

The white noise susceptibility test method is performed by injecting a desired signal and a white noise signal, with the same or greater bandwidth as that of the victim receiver, directly into the receive antenna port and observing the impact at the output of the receiver.

5.3.1 White Noise Test Objective

The objective of this test is to determine the impact of white noise signals on a receiver and determine the susceptibility threshold as a function of the white noise signal parameters.

5.3.2 White Noise Test Setup

The test setup is shown in Figure 2.

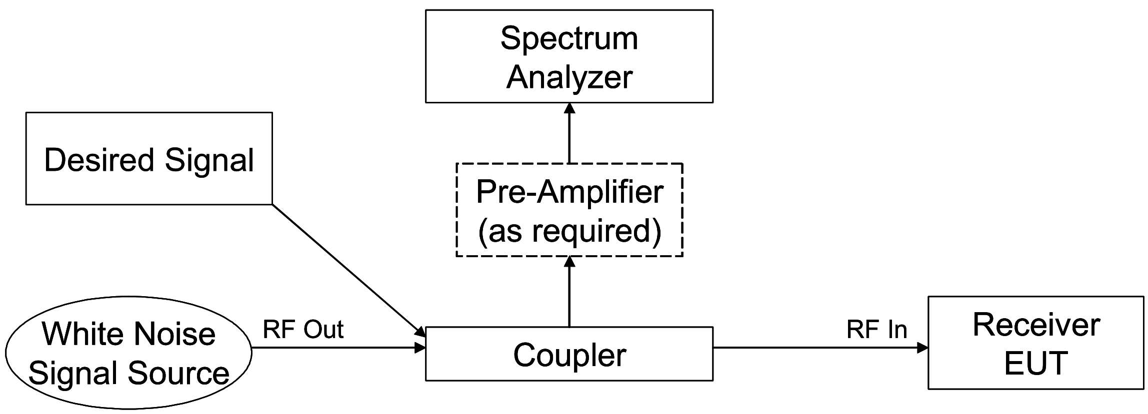

Figure 2. Set-Up for White Noise Susceptibility Test

5.3.3 White Noise Test Procedure

9. Set up AN/ARC-210 for fixed frequency operation in the UHF band.

10. Input the desired signal at a frequency of 242.5 MHz and at the standard response level.

11. Inject the white noise signal into the receiver input at a level that is at least 10 dB above the receiver standard response level. The noise level shall be high enough to mask the desired signal at the receiver output. The average noise level shall be measured using the spectrum analyzer with a resolution bandwidth of 1 kHz, 30 kHz or 1 MHz (or similar bandwidths). The bandwidth shall be selected so it is the highest of the three choices that is less than the receiver IF bandwidth. Empirical or calculated bandwidth correction factors shall be used to adjust the readings to the IF bandwidth of the receiver. Increase the desired signal level to

obtain a standard response condition. Record the desired and noise interfering signal levels on the data sheet in Table 4.

12. Repeat steps 1 through 3 at frequencies of 312.5 MHz and 382.5 MHz.

13. Repeat steps 1 through 3 for frequency hopping mode. The hopset used shall be the same as used in Section 5.2 Receiver Sensitivity Measurement – Frequency - Hopping Mode.

5.3.4 White Noise Test Output

The test output will define white noise waveform conditions that result in EMI.

Table 4. DATA SHEET FOR WHITE NOISE TESTS

Receiver: AN/ARC-210 UHF HAVE QUICK Mode
Frequency Band: 225 MHz to 400 MHz
Receiver Mode: Fixed Tuned, Frequency Hopping (Circle applicable mode)
Test Frequencies: 242.5 MHz, 312.5 MHz, 382.5 MHz (Circle applicable frequency)
Standard Response Criterion: 10 dB SINAD
Desired Signal Modulation: AM
IF Bandwidth: 25 kHz
Sensitivity: -103 dBm

	SIGNAL LEVEL (dBm)	NOISE LEVEL (dBm)
STANDARD RESPONSE LEVEL		N/A
LEVEL WHERE NOISE MASKS SIGNAL		
STANDARD RESPONSE LEVEL WITH NOISE		

5.4 One Signal Susceptibility Test Method

The one signal susceptibility test method is performed by injecting a UWB signal, with the appropriate waveform parameters as defined in Section 4.0, directly into the receive antenna port and observing the impact at the output of the receiver. If the receiver exhibits a change in the output as a result of the injected interfering signal, the receiver is considered to be susceptible. The change in the output may be manifested as a change in the output noise, the production of an interfering signal at the receiver output, activation of the receiver automatic gain control, etc.

5.4.1 One Signal Susceptibility Test Objective

The objective of this test is to determine the impact of UWB signals on a receiver and determine the susceptibility threshold as a function of the UWB signal parameters.

5.4.2 One Signal Susceptibility Test Setup

The test setup is shown in Figure 3.

5.4.3 One Signal Susceptibility Test Procedure

The procedure is to inject a UWB signal into the receiver input and observe the receiver output for any change that may provide an indication of susceptibility. Examples of indications of susceptibility are changes in the output noise, the production of an interfering signal at the output, activation of the receiver automatic gain control, etc. The tests shall be conducted for each of the applicable UWB waveforms identified in Section 4.0 and at each of the frequencies specified in Section 5.3. The UWB interference upset (IUPSET) conditions that provided an indication of susceptibility shall be recorded in Table 7.

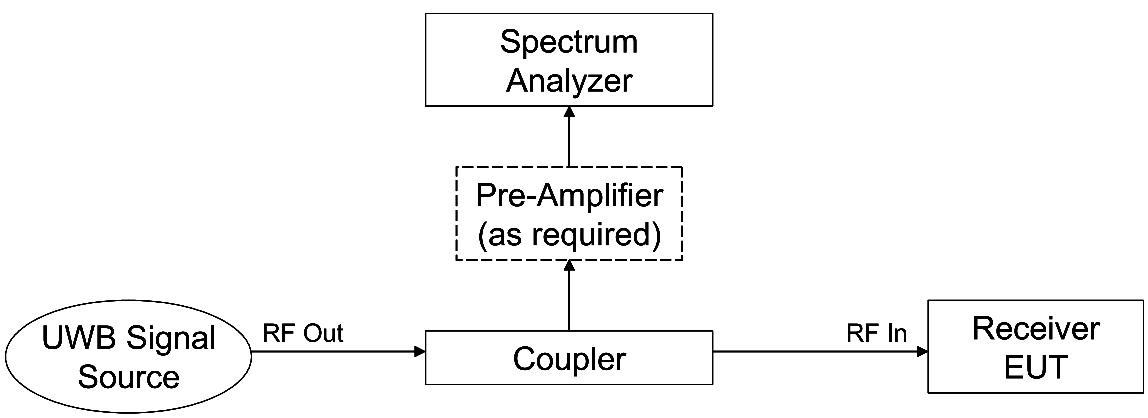

Figure 3. Setup For One Signal Susceptibility Test

Table 5. DATA SHEET FOR ONE SIGNAL SUSCEPTIBILITY TEST

Receiver: AN/ARC-210 UHF HAVE QUICK Mode
Frequency Band: 225 MHz to 400 MHz
Receiver Mode: Fixed Tuned
Test Frequencies: 242.5 MHz, 312.5 MHz, 382.5 MHz
Standard Response Criterion: 10 dB SINAD
Desired Signal Modulation: AM
IF Bandwidth: 25 kHz
Sensitivity: -103 dBm

RX FRQ (MHz)	UWB SIGNAL	PRF (MHz)	UWB MOD	IUPSET (dBm)
242.5	1	80.8	NONE	
	2	80.8	DITHERED ± 8.75 kHz	
	3	0.025	DITHERED ± 17.5 kHz	
	4	0.025	OOK	
	5	0.0025	NONE	
	6	0.250	NONE	
	7	0.250	DITHERED ± 4.375 kHz	
	8	Low Duty Factor (LDF)	NONE	
	8	High Duty Factor (HDF)	NONE	
	9	LDF	NONE	
	9	Medium Duty Factor (MDF)	NONE	
	9	HDF	NONE	
	10	LDF	NONE	
	10	HDF	NONE	

Note that the spectrum analyzer resolution and video bandwidths will not be as wide as the RF bandwidth of the UWB waveform. The resolution bandwidth (RBW) of the spectrum analyzer shall be 30 kHz or the spectrum analyzer RBW closest to, but not exceeding, 35 kHz. The spectrum analyzer video bandwidth (VBW) shall be equal to or greater than the RBW. Empirical or calculated bandwidth correction factors shall be used to adjust the measurement of the UWB waveform to the IF bandwidth of the receiver. Average measurements shall be made for all of the test waveforms except for Waveform Five which shall be made as a peak measurement. Record the interfering signal conditions (signal parameters and levels) that cause an impact on the receiver output.

5.4.4 One Signal Susceptibility Test Output

The test output will define UWB waveform conditions that result in EMI.

5.5 Two Signal Susceptibility Test - Fixed Frequency – Standard Response Desired Signal

5.5.1 Two Signal Susceptibility Test - Fixed Frequency – Standard Response Desired Signal Test Objective

The objective of this EMI test is to determine the susceptibility of an AN/ARC-210 receiver to UWB interfering signals. Susceptibility thresholds will be determined by monitoring the output of the receiver and/or measuring the BER for the information data.

5.5.2 Two Signal Susceptibility Test - Fixed Frequency – Standard Response Desired Signal Test Setup

The test setup is shown in Figure 4.

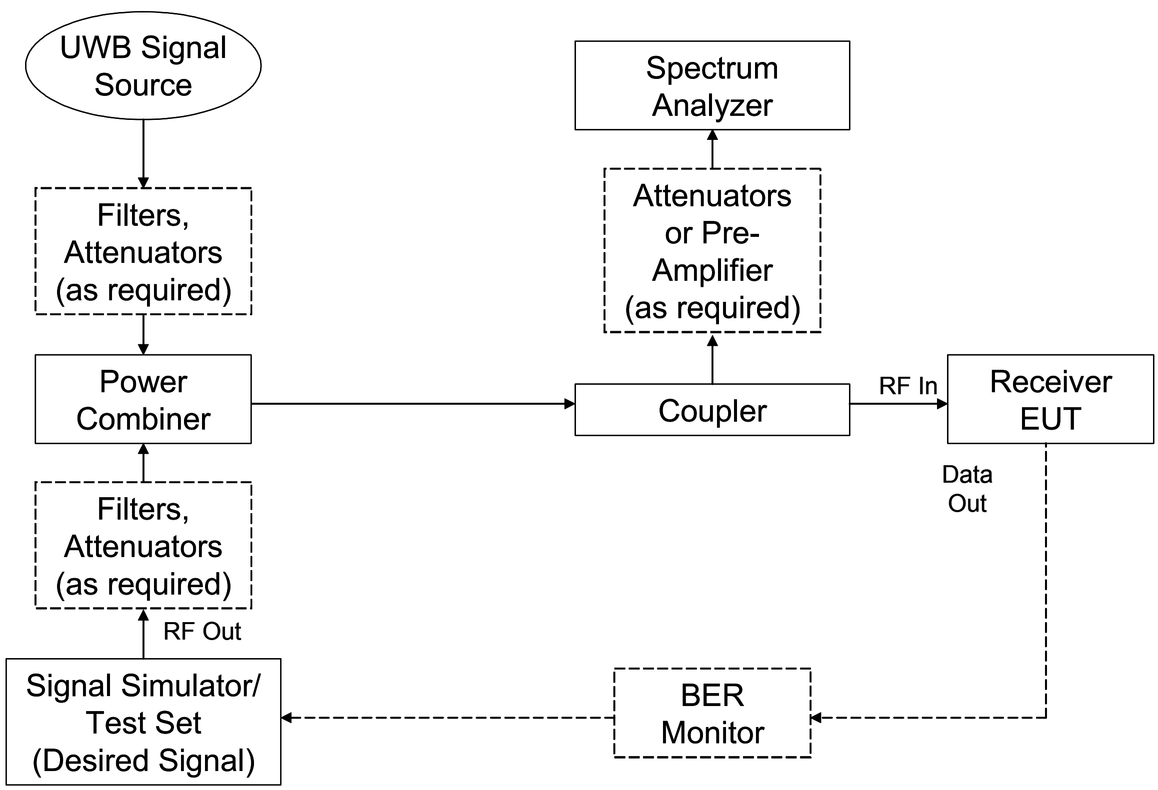

Figure 4. Conducted Susceptibility Test Set-Up-Two Signal Method

5.5.3 Two Signal Susceptibility Test - Fixed Frequency – Standard Response Desired Signal Test Procedure

The two signal susceptibility test procedure should define the performance impact that a receiver will sustain as a result of EMI from a UWB signal. In order to obtain meaningful results, it is necessary to use a desired signal level that is sufficiently above the receiver noise level to minimize the impact of receiver noise on performance.

The receiver standard response level is often defined in terms of the signal level required to produce a SINAD equal to 10 dB at the output of the receiver. If there is no interference or distortion, the 10 dB SINAD translates to a 10 dB signal-to-noise ratio. If a noise like interfering signal at the receiver noise level is added to the receiver input, the SINAD would decrease by 3 dB (i.e. from 10 dB to 7 dB). This is too close to the receiver noise and the test results may be affected by the receiver noise as well as by the UWB interference. If the desired signal is 10 dB above the receiver noise, the noise would have little impact on performance. As a result of the factors discussed , it was decided that a desired signal level that is 6 dB above the standard response level should be used for testing.

The general test procedure for determining receiver susceptibility to interference when the desired signal is 6 dB above the standard response level and the receiver is operating at a fixed frequency is as follows:

15. Tune the receiver to a test frequency of 242.5 MHz. Set the desired signal to the test frequency. Adjust the desired signal to a level that is 6 dB above the ACQ as measured in Section 5.2. Verify that the receiver output exceeds a standard response condition (i.e., SINAD is greater than 10 dB).

16. Decrease the desired signal until the level is 6 dB above the SUPSET. Record this level in Table 6 as the “desired signal level” (DSL) for the selected UWB waveform used for the tests. Verify that the receiver output exceeds the standard response condition.

17. Activate the UWB interference signal source with one of the UWB test waveforms at a level that is 20 dB below the SUPSET level recorded in Section 5.2.

18. Increase the interference signal power level until there is an indication of impact on the receiver standard response condition (i.e., a decrease in the SINAD). Record this level as the UPSET level in Table 6. Record IUPSET – DSL as the interference-to-signal ratio (I/S).

19. Set the desired signal level to 6 dB above the acquisition threshold level. Record this level as the DSL on the second row for the selected UWB waveform. Set the UWB interfering signal to the maximum level available. Decrease the UWB interference signal power until the receiver returns to a standard response

condition and all parameters are within acceptable limits. Record this interference level in Table 6 as the “interfering signal reacquisition threshold” (REACQ) level. Record REACQ – DSL as the I/S ratio.

20. Repeat Steps 1 through 5 for each of the UWB test waveforms.

21. Repeat Steps 1 through 6 for receiver operating frequencies of 312.5 MHZ and 382.5 MHz.

5.5.4 Two Signal Susceptibility Test - Fixed Frequency – Standard Response Desired Signal Test Output

The required results from the two signal EMI tests consist of recording the desired signal level (DSL), the interfering signal level for the IUPSET and REACQ and the I/S ratio on the appropriate line on the applicable data sheet for the UWB interference signal modulations and receiver modes of operation.

Table 6. TWO SIGNAL SUSCEPTIBILITY TEST WITH DESIRED SIGNAL AT STANDARD RESPONSE LEVEL

Receiver: AN/ARC-210 UHF HAVE QUICK Mode
Frequency Band: 225 MHz to 400 MHz
Test Frequencies: 242.5 MHz, 312.5 MHz, 382.5 MHz
Receiver Mode: Fixed Tuned, Frequency Hopping
Standard Response Criterion: 10 dB SINAD
Desired Signal Modulation: AM
IF Bandwidth: 25 kHz
Sensitivity: - 103 dBm

RX FRQ (MHz)	UWB SIGNAL	PRF (MHz)	UWB MOD	DSL (dBm)	IUPSET (dBm)	REACQ (dBm)	I/S (dB)
242.5	**1**	**80.8**	**NONE**			**X**	
	1	**80.8**	**NONE**		**X**		
	2	**80.8**	**DITHERED ± 8.75 kHz**			**X**	
	2	**80.8**	**DITHERED ± 8.75 kHz**		**X**		
	3	**0.025**	**DITHERED ± 17.5 kHz**			**X**	
	3	**0.025**	**DITHERED ± 17.5 kHz**		**X**		
	4	**0.025**	**MODULATED**			**X**	
	4	**0.025**	**MODULATED**		**X**		
	5	**0.0025**	**NONE**			**X**	
	5	**0.0025**	**NONE**		**X**		
	6	**0.250**	**NONE**			**X**	
	6	**0.250**	**NONE**		**X**		
	7	**0.250**	**DITHERED ± 4.375 kHz**			**X**	
	7	**0.250**	**DITHERED ± 4.375 kHz**		**X**		
8	**LDF**	**NONE**			X	**8**	**LDF**
8	**LDF**	**NONE**		X		**8**	**LDF**
8	**HDF**	**NONE**			X	**8**	**HDF**
8	**HDF**	**NONE**		X		**8**	**HDF**
9	**LDF**	**NONE**			X	**9**	**LDF**
9	**LDF**	**NONE**		X		**9**	**LDF**
9	**MDF**	**NONE**			**X**	**9**	**MDF**
9	**MDF**	**NONE**		**X**		**9**	**MDF**

RX FRQ (MHz)	UWB SIGNAL	PRF (MHz)	UWB MOD	DSL (dBm)	IUPSET (dBm)	REACQ (dBm)	I/S (dB)
9	HDF	NONE			X	9	HDF
9	HDF	NONE		X		9	HDF
10	HDF	NONE			X	10	HDF
10	HDF	NONE		X		10	HDF
10	LDF	NONE			X	10	LDF
10	LDF	NONE		X		10	LDF

5.6 Two Signal Susceptibility - Fixed Frequency – High Level UWB Signal

5.6.1 Two Signal Susceptibility - Fixed Frequency – High Level UWB Signal Test Objective

The objective of this test is to determine the impact of a high level UWB interfering signal on a receiver. The tests will determine the desired signal level that is required for the receiver to operate in a satisfactory manner with a high level UWB interfering signal (e.g., 20 dB above the receiver sensitivity) present.

5.6.2 Two Signal Susceptibility - Fixed Frequency – High Level UWB Signal Test Setup

The test setup is similar to the setup shown in Figure 5. The only differences between this test and the previous test (i.e., the two signal test with the desired signal set at a standard response level) are the levels of the desired and UWB interfering signals.

5.6.3 Two Signal Susceptibility - Fixed Frequency – High Level UWB Signal Test Procedure

The test procedure for determining the desired signal level required for satisfactory operation when a high level interfering signal is present is as follows:

11. Select a UWB waveform from the list presented in Section 4. Adjust the UWB signal so the inband components of the UWB signal are 20 dB above the receiver sensitivity or are at the maximum power available from the pulse generator. Record this level as the ISL in Table 7

12. Tune the desired signal and the receiver to 242.5 MHz. Inject the desired signal at a level that is below the standard response level. Increase the desired signal level until the receiver achieves a standard response condition. Record the desired and interfering signal levels for the ACQ in Table 7. Record ISL - ACQ as the I/S in Table 7.

13. Decrease the desired signal level until upset occurs. Record this level as SUPSET in Table 7. Record ISL - SUPSET as the I/S in Table 7.

14. Repeat steps 1 through 3 for each of the UWB waveforms listed in Section 4.0.

15. Repeat steps 1 through 4 for each of the test frequencies of 312.5 MHZ and 382.5 MHz.

5.6.4 Two Signal Susceptibility - Fixed Frequency – High Level UWB Signal Test Output

Record the interfering signal level (ISL) and the desired signal level for the condition where ACQ and SUPSET occurred on the appropriate line on the applicable data sheet provided in Table 7.

5.7 Two Signal Susceptibility Frequency Hopping – Standard Response Desired Signal

5.7 .1 Two Signal Susceptibility Frequency Hopping – Standard Response Desired Signal Test Objective

The objective of this test is to determine the IUPSET for an AN/ARC-210 receiver operating in a frequency-hopping mode with the desired signal 6 dB above the SUPSET and to determine the REACQ with the intended signal 6 dB above the ACQ.

Table 7. TWO SIGNAL SUSCEPTIBILITY TEST WITH HIGH LEVEL UWB SIGNAL

Receiver: AN/ARC-210 UHF HAVE QUICK Mode
Frequency Band: 225 MHz to 400 MHz
Test Frequencies: 242.5 MHz, 312.5 MHz, 382.5 MHz
Receiver Mode: Fixed Tuned, Frequency Hopping
Standard Response Criterion: 10 dB SINAD
Desired Signal Modulation: AM
IF Bandwidth: 25 kHz
Sensitivity: - 103 dBm

RX FRQ (MHz)	UWB SIGNAL	PRF (MHz)	UWB MOD	ISL (dBm)	ACQ (dBm)	SUPSET (dBm)	I/S (dB)
242.5	1	80.8	NONE			X	
	1	80.8	NONE		X		
	2	80.8	DITHERED ± 8.75 kHz			X	
	2	80.8	DITHERED ± 8.75 kHz		X		
	3	0.025	DITHERED ±			X	

RX FRQ (MHz)	UWB SIGNAL	PRF (MHz)	UWB MOD	ISL (dBm)	ACQ (dBm)	SUPSET (dBm)	I/S (dB)
			17.5 kHz				
	3	0.025	DITHERED ± 17.5 kHz		X		
	4	0.025	MODULATED			X	
	4	0.025	MODULATED		X		
	5	0.0025	NONE			X	
	5	0.0025	NONE		X		
	6	0.250	NONE			X	
	6	0.250	NONE		X		
	7	0.250	DITHERED ± 4.375 kHz			X	
	7	0.250	DITHERED ± 4.375 kHz		X		
	8	LDF	NONE			X	
	8	LDF	NONE		X		
	8	HDF	NONE			X	
	8	HDF	NONE		X		
	9	LDF	NONE			X	
	9	LDF	NONE		X		
	9	MDF	NONE			X	
	9	MDF	NONE		X		
	9	HDF	NONE			X	
	9	HDF	NONE		X		
	10	HDF	NONE			X	
	10	HDF	NONE		X		
	10	LDF	NONE			X	
	10	LDF	NONE		X		

5.7.2 Two Signal Susceptibility Frequency Hopping – Standard Response Desired Signal Test Setup

The test setup is shown in Figure 5.

5.7.3 Two Signal Susceptibility Frequency Hopping – Standard Response Desired Signal Test Procedure

1. Setup the signal simulator and the receiver to operate with a selected hopset. Adjust the desired signal to a level that is 6 dB above the ACQ level determined in Section 5.2. Verify that the receiver has locked onto the desired signal and a standard response condition has been achieved.

2. Decrease the desired signal to a level that is 6 dB above the SUPSET. Record this level as DSL on Table 6. Verify that the receiver output exceeds a standard response condition.

3. Activate the UWB interference signal source with one of the UWB test waveforms listed in Section 4.0 at a level that is 10 dB below the “desired signal upset threshold” level.

4. Increase the interference signal power level until the output drops out of the standard response condition. Record this level as the IUPSET level. Record IUPSET – DSL as the I/S ratio in Table 6.

5. Set the desired signal to 6 dB above the acquisition threshold level and set the UWB signal to the maximum level available. Decrease the interference signal power until the receiver is operating with an acceptable BER and all parameters are within acceptable limits. Record this interference level as the REACQ in Table 6. Record REACQ – DSL as the I/S ratio.

6. Repeat Steps 1 through 5 for each different UWB waveform listed in Section 4.0.

5.7.4 Two Signal Susceptibility Frequency Hopping – Standard Response Desired Signal Test Output

Record the ACQ, DSL, IUPSET, REACQ and I/S on the appropriate lines of the applicable data sheet in Table 6.

5.8 Frequency Hopping Mode - High Level UWB Signal

5.8.1 Frequency Hopping Mode - High Level UWB Signal Test Objective

The objective of this EMI test is to determine the susceptibility of the AN/ARC-210 receiver to high level UWB signals (20 dB above the receiver sensitivity) when the receiver is operating in a frequency-hopping mode.

5.8.2 Frequency Hopping Mode - High Level UWB Signal Test Setup

The test setup is shown in Figure 5.

5.8.3 Frequency Hopping Mode - High Level UWB Signal Test Procedure

The test procedure for determining the desired signal level required for satisfactory operation when a high level interfering signal is present and the receiver is operating in a frequency-hopping mode is as follows:

1. Select a set of waveform parameters from those listed in Section 4.0. Adjust the UWB signal so the inband components are at a level that is 20 dB above the receiver minimum standard response or are at the maximum power available from the UWB generator. Record this level as ISL in Table 7.

2. Increase the desired signal until the receiver acquires synchronization and there is a standard response condition at the output. Record this level as the ACQ in Table 7. Record ACQ – ISL as the S/I ratio in Table 7.

3. Decrease the desired signal level until the receiver exhibits unacceptable performance. Record this level as the SUPSET in Table 7. Record SUPSET – ISL as the S/I ratio in Table 7.

4. Repeat Steps 1 through 3 for each different UWB waveform listed in Section 4.0.

5.8.4 Frequency Hopping Mode - High Level UWB Signal Output

Record the interfering signal level and the desired signal level for the condition where “acquisition” and “upset” occurred and calculate and record the interference to signal ratios on the appropriate lines on the applicable data sheet provided in Table 7.

APPENDIX D
UWB EMI TEST PLAN FOR THE AN/ARC-210 VHF SINCGARS MODE

1.0 INTRODUCTION

The AN/ARC-210 very high frequency/ultra high frequency (VHF/UHF) Communication System is a line-of-sight, multi-mode transmitter/receiver system incorporating advanced electromagnetic counter-counter measures (ECCM) techniques. The AN/ARC-210 emulates the Single Channel Ground and Airborne Radio System (SINCGARS) in the VHF band (30 MHZ to 88 MHz) and emulates the HAVE QUICK radio in the UHF band (225 MHz to 400 MHz). The AN/ARC-210 uses frequency modulation (FM) in the 30 MHz to 88 MHz band and both amplitude modulation (AM) and FM in the 225 MHz to 400 MHz band. In addition, the radio is capable of providing AM operation in the 108 MHz to 156 MHz band and FM operation in the 156 MHz to 174 MHz band. The nominal sensitivity of the receiver is –103 dBm for AM operation and –108 dBm for FM operation. The system can operate in either fixed frequency or frequency-hopping modes with 25 kHz channel spacings. This test plan is for the AN/ARC-210 operating in the VHF SINCGARS Mode.

2.0 OVERALL TEST OBJECTIVE

The overall objective of the test is to determine the electromagnetic interference (EMI) susceptibility of the AN/ARC-210 (operating in the SINCGARS Mode) to conducted ultra-wideband (UWB) signals that are injected into the receiver antenna port. The results of this investigation will provide the information necessary to evaluate the potential for UWB signals to interfere with the AN/ARC-210 and to understand how UWB systems could be implemented to make use of their unique capabilities without causing EMI.

3.0 TEST APPROACH

In order to accomplish the test objective, there are several parameters that must be measured. These parameters are the sensitivity of the receiver to the desired signal and the susceptibility of the receiver to noise and selected UWB interfering signals. The test will be performed for the receiver operating in both fixed tuned and frequency-hopping modes.

The tests will be performed at the Naval Air Warfare Center Aircraft Division (NAWC AD) Electromagnetic Environmental Effects (E^3) facility by personnel that are familiar with EMI test equipment and are knowledgeable about EMI test procedures and techniques. For the type of scientific testing required for this project, detailed "cookbook" test procedures may be too restrictive and may impede testing. Therefore, detailed test procedures are not considered to be necessary and will not be provided in this test plan. Instead, the plan outlines procedures that will be dynamically adapted during the tests and recorded to ensure consistency and repeatability.

4.0 UWB WAVEFORMS

The UWB waveform parameters that will be used for the AN/ARC-210 receiver shall be selected from the set of waveforms that are presented below. When a filtered baseband pulse waveform is used, the frequency band for the UWB signal shall be selected so the receiver operating band (30 MHz to 88 MHz) falls within the UWB signal band. When the waveform is generated by an unfiltered baseband pulse, the selection of the frequency band does not apply.

The first five waveforms described below should provide the most EMI impact on a receiver. If none of the first five waveforms produce significant EMI impact on the EUT, the impact with other waveforms will be negligible and the testing can end at this point. If any of the first five waveforms result in EMI, additional testing shall be performed using waveforms 6 and 7 to provide a better characterization of the impact.

After completion of testing for the victim specific waveform, each victim will be tested using both of the generic phase shift UWB "Communication" Waveforms, Waveforms 8 and 9, and the generic On-OFF Keying (OOK) UWB "Communication" Waveforms, Waveform 10. These waveforms have been designed to simulate idealized actual UWB communications code schemes and will provide an indication of the EMC of such special codes.

4.1 Test Waveform One (TW1)

For the first test waveform, the pulse repetition frequency (PRF) shall be the maximum value available from the pulse generator that results in the fundamental or a harmonic of the PRF falling within the tuning range of the receiver.[4] For the AN/ARC-210 operating in the SINCGARS Mode the test frequencies will be 35.8 MHz, 59 MHz and 82.2 MHz. The corresponding PRFs for the first test waveform shall be equal to the test frequency. This first test waveform shall not be dithered or modulated. For this case, only one spectral line will fall within the intermediate frequency (IF) passband and the IF signal will appear to be a continuous wave (CW) signal. The receiver shall be tuned to the spectral line.

4.2 Test Waveform Two (TW2)

For the second test waveform, the basic PRF shall be the same as described for the first test waveform. However, the pulses shall be randomly dithered to fill 50% of the IF passband. This will result in a noise like signal in the IF passband and the receiver shall be tuned for maximum impact from the UWB signal.

[4] Note that the reference frequency for the UWB pulse generator is the PRF. Therefore, the terms fundamental and harmonic refer to the fundamental and harmonics of the PRF.

4.3 Test Waveform Three (TW3)

For the third test waveform, the PRF shall be 25 kHz. The pulses shall be dithered randomly to fill 100% of the IF passband. This will result in a noise like signal across the tuning range of the receiver.

4.4 Test Waveform Four (TW4)

For the fourth test waveform, the PRF shall be 25 kHz. The signal shall not be dithered but the waveform shall be modulated with on-off keying (OOK). This type of UWB interfering signal will result in a modulated signal in the IF passband and the receiver shall be tuned for a maximum impact from the UWB interference.

4.5 Test Waveform Five (TW5)

For the fifth test waveform, the PRF shall be 2.5 kHz. The waveform shall not be modulated or dithered. For this case, the PRF will be slow relative to the IF response time so the individual pulses will appear in the IF (however, the pulse width will be increased and the peak power will be reduced). For this waveform approximately 10 spectral lines will fall within the IF passband.

4.6 Test Waveform Six (TW6)

For the sixth test waveform, the PRF shall be 250 kHz and the pulses shall not be dithered or modulated. For this case, the PRF will be fast relative to the IF response time. Therefore, the signal will appear to be continuous and the effect will be that of a CW signal. Only one spectral line can fall within the IF passband and there should be a spectral line in every tenth channel. To the extent possible the receiver shall be tuned to the spectral line closest to the designated test frequency.

4.7 Test Waveform Seven (TW7)

For the seventh test waveform, the PRF shall be 250 kHz and the pulses shall be dithered randomly to cover 25% of the IF bandwidth. This will result in a noise like signal in the IF passband for every tenth channel and the receiver shall be tuned for a maximum impact from the UWB waveform.

4.8 Test Waveform Eight (TW8)

The eighth test waveform is a stream of doublets with random initial phase orientation. The value of the symbol is determined by the phase relationship of the two pulses in the doublet as shown in Table 1. The two pulses in the doublet are separated by about 1 ns. Doublets themselves have burst repetition interval (BRI) of about 267 ns apart, allowing for a data rate of about 3.75 Mb/s for a high data rate or about 15.625 µs apart, allowing for a data rate of about 64 kb/s for a low data rate. The high data rate timing retains the ratio of peak to average spectral density described in the recent FCC ruling.

Table 1. Pseudorandom Noise Doublet Symbol Mapping

	Data = 0	Data = 1
PN = 0	+ +	+ -
PN = 1	- -	- +

Data is sent in packets of 1200 bits. This includes 1024 of payload data plus 176 bits of header. High data rate packets would be sent at the 3.75 Mp/s rate and last 320 µs. The packets would occur once every 8 ms and the packets would occur once every 8 ms. Low data rate packets would be sent at the 64 kp/s rate and last 18.75 ms and the packet would occur once every 468.75 ms. The payload data would be random, or all ones, or all zeros. The header data would be the same for each packet. Use all ones or all zeros for the header.

4.9 Test Waveform Nine (TW9)

The ninth test waveform is a stream of doublets with fixed initial phase orientation. The value of the symbol is determined by the phase relationship of the two pulses in the doublet as shown in Table 2. The two pulses in the doublet are separated by about 5.708 ns. Doublets themselves have burst repetition interval (BRI) of about 17.123 ns apart, allowing for a data rate of about 58.4 Mb/s. The code has a maximum length 0f 1023 bits. This pulse spacing provides a spectrum with nulls every 175.2 MHz.

Table 2. Constant Phase Doublet Symbol Mapping

DATA	SYMBOL
0	- +
1	+ -

This waveform has three data rates based on the initial 58.4 Mb/s base data rate. The high data rate is simply a continuous stream at this rate. The medium data rate sends a burst of 1023 random symbols with a 175.17 µs BRI for a 10% burst duty factor. The low data rate sends a burst of 1023 random symbols with a 1.7517 ms BRI for a 1% burst duty factor.

4.10 Test Waveform Ten (TW10)

The tenth test waveform is an OOK pattern. Bit spacing is about 5 ns. Every 206 µs a training preamble of constant data rate pulses is sent. There is only one data rate for this waveform.

5.0 RECEIVER SUSCEPTIBILITY TEST

The objective of the receiver susceptibility tests is to obtain data that will provide useful information on the susceptibility of AN/ARC-210 receivers to UWB interference. The tests will be performed using either one or two signals. With the one signal tests, a UWB interfering signal is input to the receiver under test and the output is observed. The receiver is considered to be susceptible if the UWB interfering signal produces a detectable change in the receiver output. No intended in-band signal is used for this test. For the AN/ARC-210, the concern is that EMI may cause changes in the output of the receiver that will impact the desired functionality of the received signal. The changes in the output of the receiver may be manifested as: a change in the output noise; the production of interference at the output; or, activation (of the automatic gain control, etc).

The two signal susceptibility tests described in this test plan require that the receiver desired signal and a UWB interfering signal be simultaneously injected into the receiver antenna port. The concern is that EMI can degrade the performance of the AN/ARC-210. The baseline performance is defined in terms of a standard response that is used to determine receiver sensitivity and provides the basis for the susceptibility tests. For the AN/ARC-210, the standard response is usually defined in terms of a signal to interference, noise, and distortion (SINAD) ratio or a bit error rate (BER). The sensitivity is measured before the susceptibility tests are performed.

There are two approaches that may be used for the two signal susceptibility tests. For the first approach, the desired signal level is fixed at a level that is 6 dB above the standard response level and the receiver susceptibility to UWB interference is determined by slowly increasing the UWB signal strength until the receiver can no longer maintain a standard response. The susceptibility level describes the effect of the UWB interfering signal when the desired signal is close to the standard response level.

For the second approach, a high level UWB interfering signal (e.g., 20 dB above the receiver sensitivity) is injected and the desired signal level that is required for satisfactory operation of the receiver is determined. The information obtained from this test may be used to determine the reduction in range that the receiver will experience as a result of UWB interference. These levels are a better indication of the degradation resulting from UWB interference when the receiver has significant desired signal to operate with and is more typical of normal operations.

5.1 Receiver Sensitivity Measurement – Fixed Frequency Mode

The receiver sensitivity level is specified as the signal level required to create an appropriate standard response that results in satisfactory operation of the receiver. For operation of the AN/ARC-210 in a fixed frequency mode, the standard response is the level that results in a SINAD equal to 10 dB. The receiver sensitivity is measured using an on-tune desired signal that contains the normal receiver modulation.

5.1.1 Receiver Sensitivity Measurement – Fixed Frequency Mode Objective

The objective of this test is to determine the sensitivity of the AN/ARC-210 receiver operating in a fixed frequency mode.

5.1.2 Receiver Sensitivity Measurement – Fixed Frequency Mode Test Set-Up

The test set-up diagram for the receiver sensitivity test is shown in Figure 1.

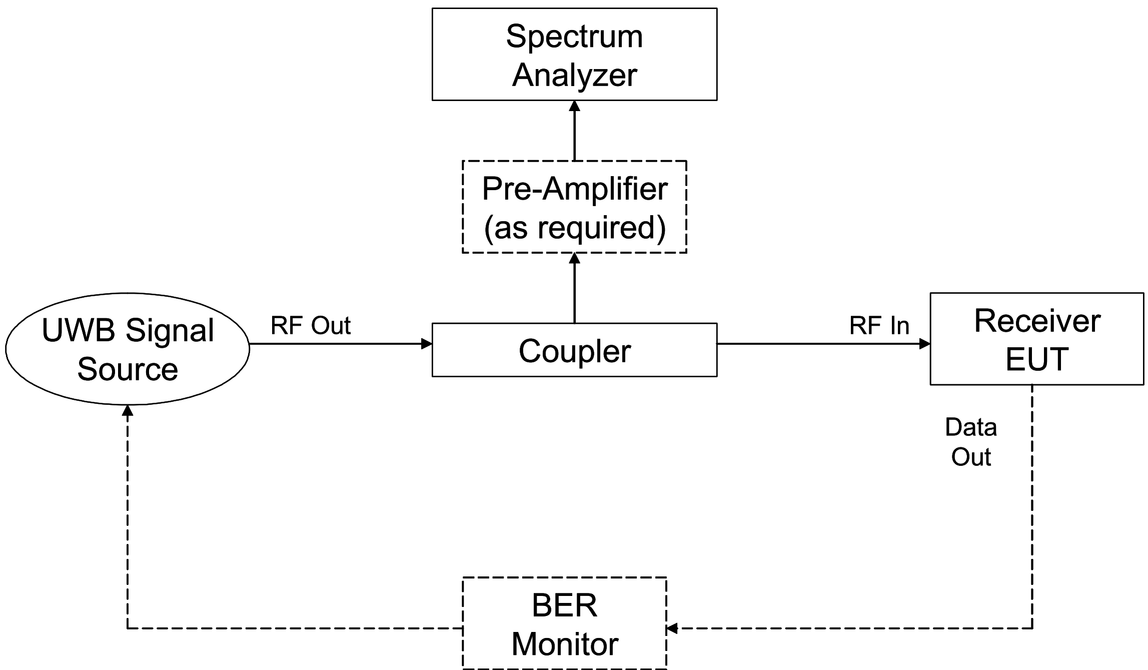

Figure 1. Receiver Sensitivity Test Set-Up

A signal generator or a signal simulator is used to generate the signal used for the test. A spectrum analyzer is used to monitor and measure the signal level at the input to the receiver EUT. A pre-amplifier connected at the input of the spectrum analyzer may be required to observe the signal during the sensitivity test. Alternatively, after the sensitivity level is established, the signal level can be raised by a known, fixed amount (e.g., 40 dB) to enable the spectrum analyzer measurement to be made.

Spectrum analyzer levels shall be corrected for the pre-amplifier gain (if used) plus coupler and/or cable losses that exist in the measurement system. The receiver operation is verified to be satisfactory by monitoring the receiver output and/or measuring the BER of the information data.

5.1.6 Receiver Sensitivity Measurement – Fixed Frequency Mode Test Procedure

The general test procedure for determining receiver sensitivity for operation in a fixed frequency mode is as follows:

19. Tune the receiver to a test frequency. Set the desired signal simulator to the tuned frequency of the receiver and adjust the output power to a level that is at least 10 dB below the receiver nominal sensitivity. The simulator signal shall be modulated in the normal manner used by the receiver and, if appropriate, coded with the receiver's internal code. Verify that the receiver has not achieved a standard response condition for the low level signal.

20. Increase the signal simulator power level until the receiver standard response level is obtained (i.e., 10 dB SINAD). Be sure to pause between each increase in signal power by an amount exceeding the maximum specified settling time for the receiver. Record this as the "standard response acquisition threshold" (ACQ) on the data sheet in Table 3.

21. Increase the input power level an additional 10 dB above the ACQ.

22. Decrease the input power level until the standard response condition is impacted. Record on the data sheet (Table 3) the input power level at which loss of the standard response was first observed. This level is termed the "signal upset threshold" (SUPSET) level. It shall be noted that ACQ and SUPSET may occur at the same level.

23. Steps 1 through 4 shall be performed at frequencies of 35.8 MHz, 59 MHz and 82.2 MHz.

24. If the receiver operates at multiple modes/rates, repeat Steps 1 through 5 while the receiver is operating at several representative modes (e.g., if the receiver operates at several data rates, make the measurements with the receiver operating at minimum, maximum, and nominal data rates).

5.1.4 Receiver Sensitivity Measurement – Fixed Frequency Mode Test Output

The required results from the receiver sensitivity test consist of documenting the ACQ and SUPSET thresholds on the data sheet provided in Table 3. An average threshold value shall be specified if significant differences exist between the thresholds determined in the multiple test trials.

Table 3. DATA SHEET FOR SENSITIVITY MEASUREMENTS

Receiver: AN/ARC-210 VHF SINCGARS Mode
Frequency Band: 30 MHZ to 88 MHz
Receiver Modes: Fixed tuned , Frequency Hopping
Test Frequencies: 35.8 MHz, 59 MHz, 82.2 MHz
Standard Response Criterion: 10 dB SINAD
Desired Signal Modulation: FM
IF Bandwidth: 25 kHz
Sensitivity: -108 dBm

RCVR FRQ (MHz)	RCVR MODE	ACQ (dBm)	SUPSET (dBm)	NOTES

NOTE: Sensitivity threshold levels are inherently statistical and thus this procedure shall be conducted multiple times to obtain a representative sample of the threshold level. Tests shall be conducted at frequencies corresponding to 10%, 50% and 90% of the tuning band.

5.2 Receiver Sensitivity Measurement – Frequency - Hopping Mode

When the receiver is operating in a frequency-hopping mode, the receiver must acquire and maintain synchronization to operate properly. For the frequency-hopping mode of operation, the receiver sensitivity may be defined in terms of the ACQ, which is the signal level required for the receiver to acquire synchronization and achieve an acceptable BER, and the SUPSET, which is the signal level required for the receiver to maintain an acceptable BER once acquisition has occurred.

5.2.1 Receiver Sensitivity Measurement – Frequency - Hopping Mode Objective

The objective of this test is to measure the ACQ and SUPSET thresholds for the AN/ARC-210 receiver operating in a frequency-hopping mode.

5.2.2 Receiver Sensitivity Measurement – Frequency - Hopping Mode Test Setup

The test setup is shown in Figure 1.

5.2.3 Receiver Sensitivity Measurement – Frequency - Hopping Mode Test Procedures

The general test procedure for determining receiver sensitivity for a frequency-hopping mode is as follows:

5. Set the signal simulator (or transmitter) and the receiver to operate with the same hopset. Adjust the output level for the desired signal simulator so it is at least 10 dB below the nominal receiver sensitivity. The simulated signal shall be modulated in the normal manner used by the receiver and, if appropriate, coded with the receiver's internal code. Verify that the receiver has not acquired synchronization with the low level signal.

6. Increase the signal simulator power level until the receiver acquires synchronization and is operating at a standard response level (e.g., a 10% BER). Be sure to pause between each increase in signal power by an amount exceeding the maximum specified settling time for the receiver. Record the input power level at which the standard response condition was acquired. This power level which is defined as the ACQ shall be recorded in Table 3.

7. Increase the input power level an additional 10 dB above the ACQ.

8. Decrease the input power level until the BER drops below an acceptable level. Record in Table 3 the input power level at which the unacceptable BER was first observed. This level is termed the SUPSET level.

NOTE: Sensitivity threshold levels are inherently statistical and thus multiple trials of this procedure, using different hopsets, shall be conducted to obtain a representative sample of the threshold level.

5.2.4 Receiver Sensitivity Measurement – Frequency - Hopping Mode Test Output

The required results from the receiver sensitivity test consist of recording the ACQ and the SUPSET on the data sheet provided in Table 3. An average threshold value shall be specified if significant differences exist between the thresholds determined in the multiple test trials.

5.3 White Noise Test Method

The white noise susceptibility test method is performed by injecting a desired signal and a white noise signal, with the same or greater bandwidth as that of the victim receiver, directly into the receive antenna port and observing the impact at the output of the receiver.

5.3.1 White Noise Test Objective

The objective of this test is to determine the impact of white noise signals on a receiver and determine the susceptibility threshold as a function of the white noise signal parameters.

5.3.2 White Noise Test Setup

The test setup is shown in Figure 2.

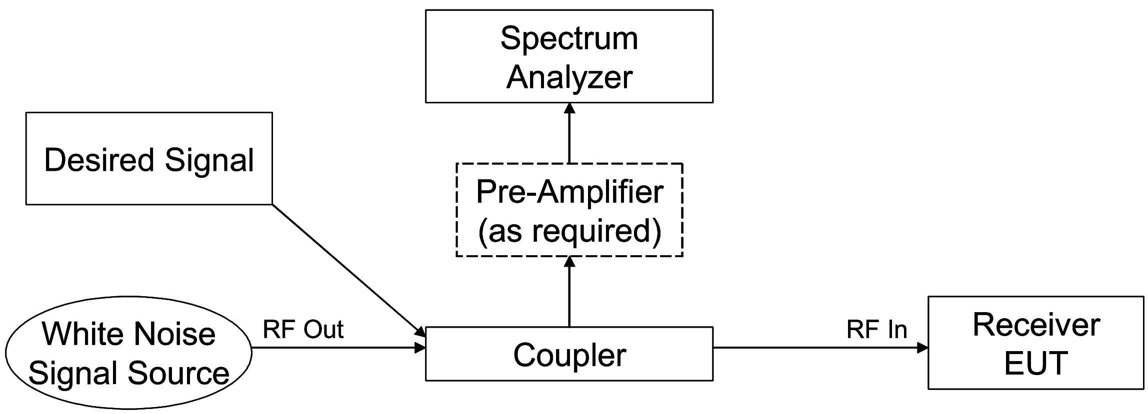

Figure 2. Set-Up for White Noise Susceptibility Test

5.3.3 White Noise Test Procedure

14. Set up AN/ARC-210 for fixed frequency operation in the VHF band.

15. Input the desired signal at a frequency of 35.8 MHz and at the standard response level.

16. Inject the white noise signal into the receiver input at a level that is at least 10 dB above the receiver standard response level. The noise level shall be high enough to mask the desired signal at the receiver output. The average noise level shall be measured using the spectrum analyzer with a resolution bandwidth of 1 kHz, 30 kHz or 1 MHz (or similar bandwidths). The bandwidth shall be selected so it is the highest of the three choices that is less than the receiver IF bandwidth. Empirical or calculated bandwidth correction factors shall be used to adjust the readings to the IF bandwidth of the receiver. Increase the desired signal level to

obtain a standard response condition. Record the desired and noise interfering signal levels on the data sheet in Table 4.

17. Repeat steps 1 through 3 at frequencies of 59 MHz and 82.2 MHz.

18. Repeat steps 1 through 3 for frequency hopping mode. The hopset used shall be the same as used in Section 5.2 Receiver Sensitivity Measurement – Frequency - Hopping Mode.

5.3.4 White Noise Test Output

The test output will define white noise waveform conditions that result in EMI.

Table 4. DATA SHEET FOR WHITE NOISE TESTS

Receiver: AN/ARC-210 VHF SINCGARS Mode
Frequency Band: 30 MHz to 88 MHz
Receiver Mode: Fixed Tuned, Frequency Hopping
Test Frequencies: 35.8 MHz, 59 MHz, 82.2
Standard Response Criterion: 10 dB SINAD Fixed Tuned; 10% BER FH
Desired Signal Modulation: FM
IF Bandwidth: 25 kHz
Sensitivity: -108 dBm

	SIGNAL LEVEL (dBm)	**NOISE LEVEL (dBm)**
STANDARD RESPONSE LEVEL		**N/A**
LEVEL WHERE NOISE MASKS SIGNAL		
STANDARD RESPONSE LEVEL WITH NOISE		

5.4 One Signal Susceptibility Test Method

The one signal susceptibility test method is performed by injecting a UWB signal, with the appropriate waveform parameters as defined in Section 4.0, directly into the receive antenna port and observing the impact at the output of the receiver. If the receiver exhibits a change in the output as a result of the injected interfering signal, the receiver is considered to be susceptible. The change in the output may be manifested as a change in the output noise, the production of an interfering signal at the receiver output, activation of the receiver automatic gain control, etc.

5.4.1 One Signal Susceptibility Test Objective

The objective of this test is to determine the impact of UWB signals on a receiver and determine the susceptibility threshold as a function of the UWB signal parameters.

5.4.2 One Signal Susceptibility Test Setup

The test setup is shown in Figure 3.

5.4.4 One Signal Susceptibility Test Procedure

The procedure is to inject a UWB signal into the receiver input and observe the receiver output for any change that may provide an indication of susceptibility. Examples of indications of susceptibility are changes in the output noise, the production of an interfering signal at the output, activation of the receiver automatic gain control, etc. The tests shall be conducted for each of the applicable UWB waveforms identified in Section 4.0 and at each of the frequencies specified in Section 5.3. The UWB interference upset (IUPSET) conditions that provided an indication of susceptibility shall be recorded in Table 5.

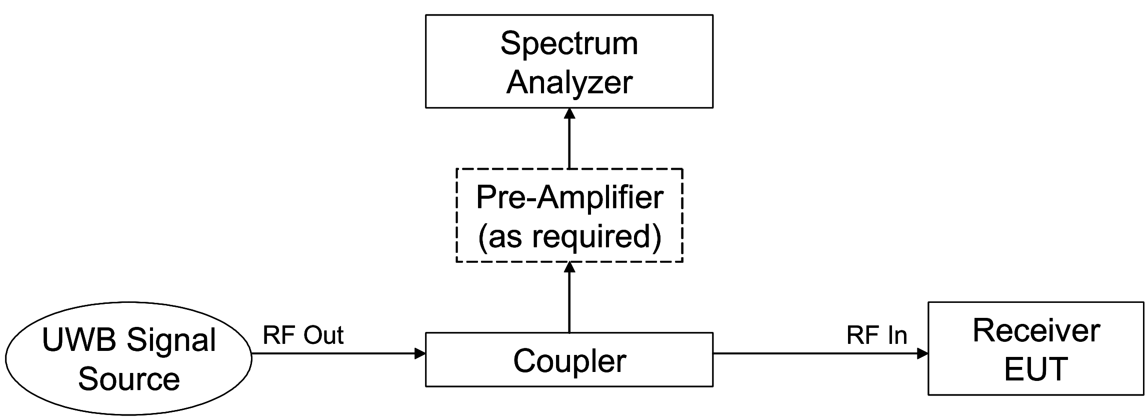

Figure 3. Setup For One Signal Susceptibility Test

Table 5. DATA SHEET FOR ONE SIGNAL SUSCEPTIBILITY TEST

Receiver: AN/ARC- 210 VHF SINCGARS Mode
Frequency Band: 30 to 88 MHz
Receiver Mode: Fixed Tuned
Test Frequencies: 35.8 MHz, 59 MHz, 82.2. MHz
Standard Response Criterion: 10 dB SINAD
Desired Signal Modulation: FM
IF Bandwidth: 25 kHz
Sensitivity: -108 dBm

RX FRQ (MHz)	UWB SIGNAL	PRF (MHz)	UWB MOD	IUPSET (dBm)
35.8	1	35.8	NONE	
	2	35.8	DITHERED ± 8.75 kHz	
	3	0.025	DITHERED ± 17.5 kHz	
	4	0.025	OOK	
	5	0.0025	NONE	
	6	0.250	NONE	
	7	0.250	DITHERED ± 4.375 kHz	
	8	Low Duty Factor (LDF)	NONE	
	8	High Duty Factor (HDF)	NONE	
	9	LDF	NONE	
	9	Medium Duty Factor (MDF)	NONE	
	9	HDF	NONE	
	10	LDF	NONE	
	10	HDF	NONE	

Note that the spectrum analyzer resolution and video bandwidths will not be as wide as the RF bandwidth of the UWB waveform. The resolution bandwidth (RBW) of the spectrum analyzer shall be 30 kHz or the spectrum analyzer RBW closest to, but not exceeding, 35 kHz. The spectrum analyzer video bandwidth (VBW) shall be equal to or greater than the RBW. Empirical or calculated bandwidth correction factors shall be used to adjust the measurement of the UWB waveform to the IF bandwidth of the receiver. Average measurements shall be made for all of the test waveforms except for Waveform Five which shall be made as a peak measurement. Record the interfering signal conditions (signal parameters and levels) that cause an impact on the receiver output.

5.4.4 One Signal Susceptibility Test Output

The test output will define UWB waveform conditions that result in EMI.

5.5 Two Signal Susceptibility Test - Fixed Frequency – Standard Response Desired Signal

5.5.1 Two Signal Susceptibility Test - Fixed Frequency – Standard Response Desired Signal Test Objective

The objective of this EMI test is to determine the susceptibility of an AN/ARC-210 receiver to UWB interfering signals. Susceptibility thresholds will be determined by monitoring the output of the receiver and/or measuring the BER for the information data.

5.5.2 Two Signal Susceptibility Test - Fixed Frequency – Standard Response Desired Signal Test Setup

The test setup is shown in Figure 4.

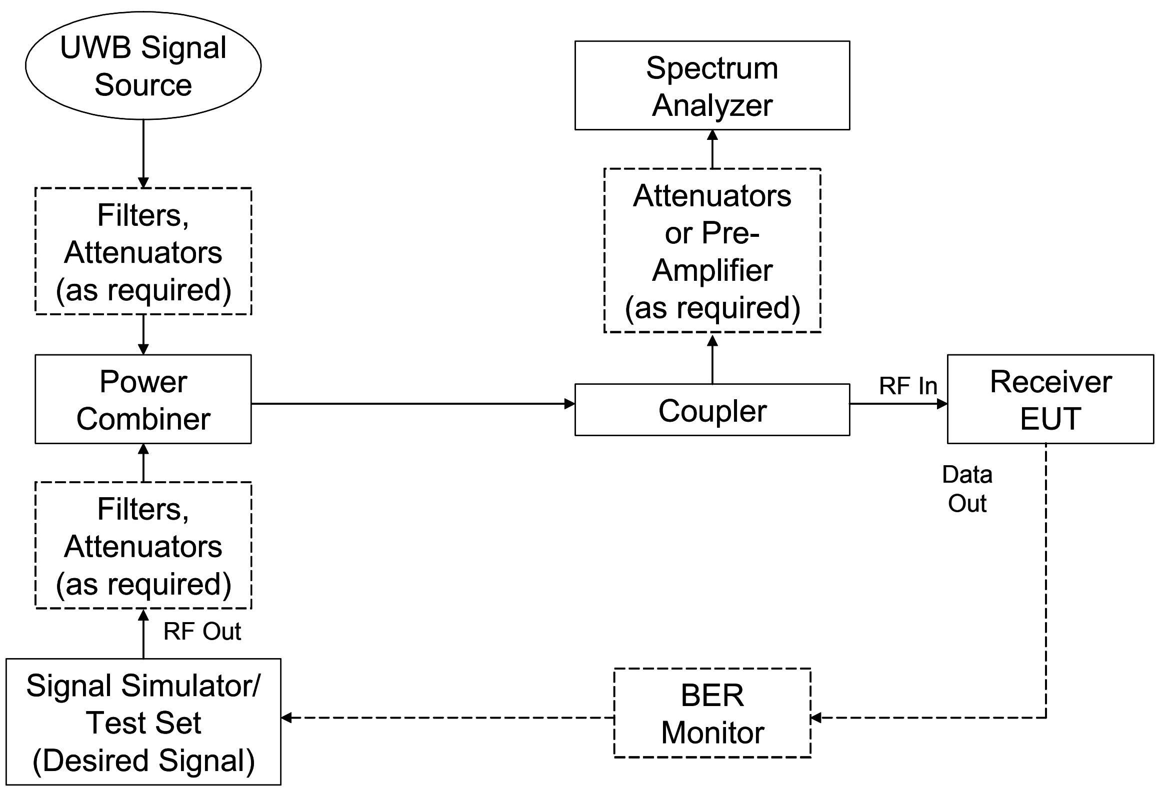

Figure 4. Conducted Susceptibility Test Set-Up-Two Signal Method

5.5.3 Two Signal Susceptibility Test - Fixed Frequency – Standard Response Desired Signal Test Procedure

The two signal susceptibility test procedure should define the performance impact that a receiver will sustain as a result of EMI from a UWB signal. In order to obtain meaningful results, it is necessary to use a desired signal level that is sufficiently above the receiver noise level to minimize the impact of receiver noise on performance.

The receiver standard response level is often defined in terms of the signal level required to produce a SINAD equal to 10 dB at the output of the receiver. If there is no interference or distortion, the 10 dB SINAD translates to a 10 dB signal-to-noise ratio. If a noise like interfering signal at the receiver noise level is added to the receiver input, the SINAD would decrease by 3 dB (i.e. from 10 dB to 7 dB). This is too close to the receiver noise and the test results may be affected by the receiver noise as well as by the UWB interference. If the desired signal is 10 dB above the receiver noise, a noise like EMI signal at the noise level would have little impact on performance. As a result of the factors discussed , it was decided that a desired signal level that is 6 dB above the standard response level should be used for testing.

The general test procedure for determining receiver susceptibility to interference when the desired signal is 6 dB above the standard response level and the receiver is operating at a fixed frequency is as follows:

22. Tune the receiver to a test frequency of 35.8 MHz. Set the desired signal to the test frequency. Adjust the desired signal to a level that is 6 dB above the ACQ as measured in Section 5.2. Verify that the receiver output exceeds a standard response condition (i.e., SINAD is greater than 10 dB).

23. Decrease the desired signal until the level is 6 dB above the SUPSET. Record this level in Table 6 as the "desired signal level" (DSL) for the selected UWB waveform used for the tests. Verify that the receiver output exceeds the standard response condition.

24. Activate the UWB interference signal source with one of the UWB test waveforms at a level that is 20 dB below the SUPSET level recorded in Section 5.2.

25. Increase the interference signal power level until there is an indication of impact on the receiver standard response condition (i.e., a decrease in the SINAD). Record this level as the UPSET level in Table 6. Record IUPSET – DSL as the interference-to-signal ratio (I/S).

26. Set the desired signal level to 6 dB above the acquisition threshold level. Record this level as the DSL on the second row for the selected UWB waveform. Set the UWB interfering signal to the maximum level available. Decrease the UWB interference signal power until the receiver returns to a standard response condition and all parameters are within acceptable limits. Record this interference level in Table 6 as the "interfering signal reacquisition threshold" (REACQ) level.

Record REACQ – DSL as the I/S ratio.

27. Repeat Steps 1 through 5 for each of the UWB test waveforms.

28. Repeat Steps 1 through 6 for receiver operating frequencies of 59 MHZ and 82.2 MHz.

5.5.4 Two Signal Susceptibility Test - Fixed Frequency – Standard Response Desired Signal Test Output

The required results from the two signal EMI tests consist of recording the desired signal level (DSL), the interfering signal level for the IUPSET and REACQ and the I/S ratio on the appropriate line on the applicable data sheet for the UWB interference signal modulations and receiver modes of operation.

Table 6. TWO SIGNAL SUSCEPTIBILITY TEST WITH DESIRED SIGNAL AT STANDARD RESPONSE LEVEL

Receiver: AN/ARC-210 VHF SINCGARS Mode
Frequency Band: 30 MHz to 88 MHz
Test Frequencies: 35.8 MHz, 59 MHz, 82.2 MHz
Receiver Mode: Fixed Tuned
Standard Response Criterion: 10 dB SINAD
Desired Signal Modulation: FM
IF Bandwidth: 25 kHz
Sensitivity: - 108 dBm

RX FRQ (MHz)	UWB SIGNAL	PRF (MHz)	UWB MOD	DSL (dBm)	IUPSE T (dBm)	REACQ (dBm)	I/S (dB)
35.8	1	35.8	NONE			X	
	1	35.8	NONE		X		
	2	35.8	DITHERED ± 6.25 kHz			X	
	2	35.8	DITHERED ± 6.25 kHz		X		
	3	0.025	DITHERED ± 12.5 kHz			X	
	3	0.025	DITHERED ± 12.5 kHz		X		
	4	0.025	MODULATED			X	
	4	0.025	MODULATED		X		
	5	0.0025	NONE			X	
	5	0.0025	NONE		X		
	6	0.250	NONE			X	
	6	0.250	NONE		X		
	7	0.250	DITHERED ± 3.12 5kHz			X	
	7	0.250	DITHERED ± 3.125 kHz		X		
	8	LDF	NONE			X	
	8	LDF	NONE		X		
	8	HDF	NONE			X	
	8	HDF	NONE		X		
	9	LDF	NONE			X	
	9	LDF	NONE		X		
	9	MDF	NONE			X	
	9	MDF	NONE		X		
	9	HDF	NONE			X	

RX FRQ (MHz)	UWB SIGNAL	PRF (MHz)	UWB MOD	DSL (dBm)	IUPSET (dBm)	REACQ (dBm)	I/S (dB)
	9	HDF	NONE		X		
	10	HDF	NONE			X	
	10	HDF	NONE		X		
	10	LDF	NONE			X	
	10	HDF	NONE		X		

5.6 Two Signal Susceptibility - Fixed Frequency – High Level UWB Signal

5.6.1 Two Signal Susceptibility - Fixed Frequency – High Level UWB Signal Test Objective

The objective of this test is to determine the impact of a high level UWB interfering signal on a receiver. The tests will determine the desired signal level that is required for the receiver to operate in a satisfactory manner with a high level UWB interfering signal (e.g., 20 dB above the receiver sensitivity) present.

5.6.2 Two Signal Susceptibility - Fixed Frequency – High Level UWB Signal Test Setup

The test setup is similar to the setup shown in Figure 5. The only differences between this test and the previous test (i.e., the two signal test with the desired signal set at a standard response level) are the levels of the desired and UWB interfering signals.

5.6.3 Two Signal Susceptibility - Fixed Frequency – High Level UWB Signal Test Procedure

The test procedure for determining the desired signal level required for satisfactory operation when a high level interfering signal is present is as follows:

16. Select a UWB waveform from the list presented in Section 4. Adjust the UWB signal so the inband components of the UWB signal are 20 dB above the receiver sensitivity or are at the maximum power available from the pulse generator. Record this level as the ISL in Table 7

17. Tune the desired signal and the receiver to 35.8 MHz. Inject the desired signal at a level that is below the standard response level. Increase the desired signal level until the receiver achieves a standard response condition. Record the desired and interfering signal levels for the ACQ in Table 7. Record ISL - ACQ as the I/S in Table 7.

18. Decrease the desired signal level until upset occurs. Record this level as SUPSET

in Table 7. Record ISL - SUPSET as the I/S in Table 7.

19. Repeat steps 1 through 3 for each of the UWB waveforms listed in Section 4.0.

20. Repeat steps 1 through 4 for each of the test frequencies of 59 MHZ and 82.2 MHz.

5.6.4 Two Signal Susceptibility - Fixed Frequency – High Level UWB Signal Test Output

Record the interfering signal level (ISL) and the desired signal level for the condition where ACQ and SUPSET occurred on the appropriate line on the applicable data sheet provided in Table 7.

5.7 Two Signal Susceptibility Frequency Hopping – Standard Response Desired Signal

5.7 .1 Two Signal Susceptibility Frequency Hopping – Standard Response Desired Signal Test Objective

The objective of this test is to determine the IUPSET for an AN/ARC-210 receiver operating in a frequency-hopping mode with the desired signal 6 dB above the SUPSET and to determine the REACQ with the intended signal 6 dB above the ACQ.

Table 7. TWO SIGNAL SUSCEPTIBILITY TEST WITH HIGH LEVEL UWB SIGNAL

Receiver: AN/ARC-210 VHF SINCGARS Mode
Frequency Band: 30 MHz to 88 MHz
Test Frequencies: 35.8 MHz, 59 MHz, 82.2 MHz
Receiver Mode: Fixed Tuned, Frequency Hopping
Standard Response Criterion: 10 dB SINAD
Desired Signal Modulation: FM
IF Bandwidth: 25 kHz
Sensitivity: - 108 dBm

RX FRQ (MHz)	UWB SIGNAL	PRF (MHz)	UWB MOD	ISL (dBm)	ACQ (dBm)	SUPSET (dBm)	I/S (dB)
35.8	1	35.8	NONE			X	
	1	35.8	NONE		X		
	2	35.8	DITHERED ± 8.75 kHz			X	
	2	35.8	DITHERED ± 8.75 kHz		X		
	3	0.025	DITHERED ± 17.5 kHz			X	

RX FRQ (MHz)	UWB SIGNAL	PRF (MHz)	UWB MOD	ISL (dBm)	ACQ (dBm)	SUPSET (dBm)	I/S (dB)
	3	0.025	DITHERED ± 17.5 kHz		X		
	4	0.025	MODULATED			X	
	4	0.025	MODULATED		X		
	5	0.0025	NONE			X	
	5	0.0025	NONE		X		
	6	0.25	NONE			X	
	6	0.25	NONE		X		
	7	0.25	DITHERED ± 4.375 kHz			X	
	7	0.25	DITHERED ± 4.375 kHz		X		
	8	LDF	NONE			X	
	8	LDF	NONE		X		
	8	HDF	NONE			X	
	8	HDF	NONE		X		
	9	LDF	NONE			X	
	9	LDF	NONE		X		
	9	MDF	NONE			X	
	9	MDF	NONE		X		
	9	HDF	NONE			X	
	9	HDF	NONE		X		
	10	HDF	NONE			X	
	10	HDF	NONE		X		
	10	LDF	NONE			X	

5.7.2 Two Signal Susceptibility Frequency Hopping – Standard Response Desired Signal Test Setup

The test setup is shown in Figure 5.

5.7.3 Two Signal Susceptibility Frequency Hopping – Standard Response Desired Signal Test Procedure

7. Setup the signal simulator and the receiver to operate with a selected hopset. Adjust the desired signal to a level that is 6 dB above the ACQ level determined in Section 5.2. Verify that the receiver has locked onto the desired signal and a standard response condition has been achieved.

8. Decrease the desired signal to a level that is 6 dB above the SUPSET. Record this level as DSL on Table 6. Verify that the receiver output exceeds a standard response condition.

9. Activate the UWB interference signal source with one of the UWB test waveforms listed in Section 4.0 at a level that is 10 dB below the "desired signal upset threshold" level.

10. Increase the interference signal power level until the output drops out of the standard response condition. Record this level as the IUPSET level. Record IUPSET – DSL as the I/S ratio in Table 6.

11. Set the desired signal to 6 dB above the acquisition threshold level and set the UWB signal to the maximum level available. Decrease the interference signal power until the receiver is operating with an acceptable BER and all parameters are within acceptable limits. Record this interference level as the REACQ in Table 6. Record REACQ – DSL as the I/S ratio.

12. Repeat Steps 1 through 5 for each different UWB waveform listed in Section 4.0.

5.7.4 Two Signal Susceptibility Frequency Hopping – Standard Response Desired Signal Test Output

Record the ACQ, DSL, IUPSET, REACQ and I/S on the appropriate lines of the applicable data sheet in Table 6.

5.8 Frequency Hopping Mode - High Level UWB Signal

5.8.1 Frequency Hopping Mode - High Level UWB Signal Test Objective

The objective of this EMI test is to determine the susceptibility of the AN/ARC-210 receiver to high level UWB signals (20 dB above the receiver sensitivity) when the receiver is operating in a frequency-hopping mode.

5.8.2 Frequency Hopping Mode - High Level UWB Signal Test Setup

The test setup is shown in Figure 5.

5.8.3 Frequency Hopping Mode - High Level UWB Signal Test Procedure

The test procedure for determining the desired signal level required for satisfactory operation when a high level interfering signal is present and the receiver is operating in a frequency-hopping mode is as follows:

5. Select a set of waveform parameters from those listed in Section 4.0. Adjust the UWB signal so the inband components are at a level that is 20 dB above the receiver minimum standard response or are at the maximum power available from the UWB generator. Record this level as ISL in Table 7.

6. Increase the desired signal until the receiver acquires synchronization and there is a standard response condition at the output. Record this level as the ACQ in Table 7. Record ACQ – ISL as the S/I ratio in Table 7.

7. Decrease the desired signal level until the receiver exhibits unacceptable performance. Record this level as the SUPSET in Table 7. Record SUPSET – ISL as the S/I ratio in Table 7.

8. Repeat Steps 1 through 3 for each different UWB waveform listed in Section 4.0.

5.8.4 Frequency Hopping Mode - High Level UWB Signal Output

Record the interfering signal level and the desired signal level for the condition where ACQ and SUPSET occurred and calculate and record the I/S ratios on the applicable data sheet provided in Table 7.

APPENDIX E
UWB EMI TEST PLAN FOR THE AN/PSN-11 PRECISION LIGHTWEIGHT GPS RECEIVER (PLGR)

1.0 INTRODUCTION

The AN/PSN-11 (PLGR) is a 5-channel military GPS receiver for handheld and vehicular applications.

2.0 OVERALL TEST OBJECTIVE

The overall objective of the test is to determine the EMI susceptibility of the primary operational modes of the PLGR to conducted UWB signals that are injected into the receiver antenna port. The results of this investigation will provide the information necessary to evaluate the potential for UWB signals to interfere with the PLGR and to understand how UWB systems could be implemented to make use of their unique capabilities without causing EMI.

3.0 TEST APPROACH

In order to accomplish the test objective, there are several performance metrics that must be measured, each of which corresponds to a major operational mode of the receiver. These metrics are the Time to First Fix (TTFF) for C/A-code acquisition, the time for Direct P/Y reacquisition, and the position accuracy and/or signal strength susceptibility for steady-state P-code tracking. For each metric, an interference substitution approach will be used to collect the relevant test data.

Only L1 susceptibility testing will be performed, because the performance impact to L2 would be equivalent when differences in satellite power levels and in band interference components are accounted for.

4.0 INTERFERENCE SUBSTITUTION TEST METHODOLOGY

The interference substitution test method is illustrated in Figure 1. The method for NETEX military GPS receiver testing is adapted from one developed by RTCA SC-159 for use in the civil aviation GPS receiver tests with UWB RFI. It first establishes the baseline receiver performance against a standard interference source (e.g., broadband noise in Fig. 1), then known portions of the standard interference power are removed an replace by measured amounts of UWB interference to give the same performance. Comparison of the amounts of UWB power added with the amounts of standard RFI source power removed yield a power equivalence factor for the particular UWB waveform in the test in terms of equal RFI effect with the standard RFI source. This equivalence factor is useful in subsequent scenario analysis and receiver effect diagnosis.

For consistency with the NETEX RFI tests on other receivers, an additional test condition is used. In that case, no stand alone RFI source power is injected and the UWB power for the i^{th} mode (Uix) is determined which causes the full RFI effect (red curve in Fig. 1). For completeness, the underlying base receiver noise (Nrx) added to the UWB power is also determined.

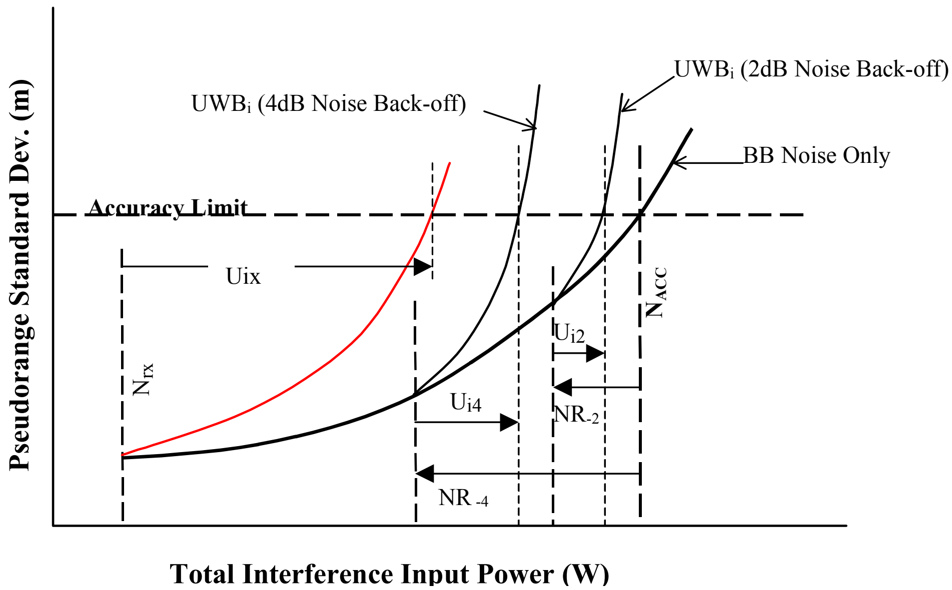

Figure 1. Interference Substitution Method for Pseudorange Std. Dev. with Broadband Noise as Standard Interference Signal

5.0 SIMULATED SATELLITE CONSTELLATION

A multiple channel satellite simulator will be used in conducting all the GPS receiver tests. This provides a more realistic test scenario because the effects on multiple PRN codes can be evaluated. This is of particular importance for C/A-code tests. The same satellite constellation scenario will be utilized in all the tests. The constellation almanac and other scenario parameters are given in Appendix A. The satellite power levels will all be maintained at -1XX dBm throughout the entire scenario.

6.0 UWB WAVEFORMS

The UWB waveform parameters that will be used for the PLGR should be selected as follows:

- If a filtered waveform is used, the frequency band for the UWB signal should be selected so the receiver operating band falls within the UWB signal band. If the waveform is generated by a base band pulse, the selection of the frequency band does not apply.

- For the first test waveform, the PRF should be the maximum value available from the pulse generator that results in the fundamental or a harmonic of the PRF falling within the tuning range of the receiver. For example, if the receiver tunes from 225 MHz to 400 MHz, the maximum PRF available from the pulse generator (100 MHz) should be used. This would result in a third harmonic at 300 MHz that would fall within the tuning range of the receiver. However, if the receiver tunes from 30 MHz to 88 MHz the PRF should be slightly below 88 MHz (e.g., 85 MHz) so the fundamental falls within the tuning range of the receiver. For a receiver that tunes from 108 MHz to 174 MHz, the PRF should be approximately 85 MHz that would result in a second harmonic of the PRF at 170 MHz that is within the receiver tuning range. This first test waveform should not be dithered or modulated. For this case, only one spectral line will fall within the IF passband and the IF signal will appear to be a continuous wave (CW) signal. The receiver should be tuned to one of the spectral lines.

- For the second test waveform, the basic PRF should be the same as described for the first test waveform. However, the pulses should be dithered. This will result in a noise like signal in the IF passband and the receiver should be tuned for maximum impact from the UWB signal.

- For the third test waveform, the PRF should be equal to the IF bandwidth of the receiver and the pulses should be dithered. This will result in a noise like signal across the tuning range of the receiver.

- For the fourth test waveform, the PRF should be 1/10 of the receiver IF bandwidth and the signal should not be dithered or modulated. For this case, the PRF will be slow relative to the IF response time so the individual pulses will appear in the IF (however, the pulse width will be increased and the peak power will be reduced). For this waveform approximately 10 spectral lines will fall within the IF passband.

- The first four waveforms described above should provide the most EMI impact that a UWB waveform will have on a receiver. If none of the four waveforms produce significant EMI impact on the EUT, the impact with other waveforms will be negligible and the testing can end at this point. If any of the first four waveforms have an EMI impact, further testing is required to better characterize the impact. The additional tests should be performed using the waveform parameters defined below.

- For the fifth test waveform, the PRF should be 10 times the receiver IF bandwidth and the pulses should not be dithered or modulated. For this case, the PRF will be fast relative to the IF response time. Therefore, the signal will appear to be continuous and the effect will be that of a CW signal. Only one spectral line can fall within the IF passband and the receiver should be tuned to one of the spectral lines.

- For the sixth test waveform, the PRF should be 10 times the receiver IF bandwidth and the pulses should be dithered but not modulated. This will result in a noise like signal in the IF passband and the receiver should be tuned for a maximum impact from the UWB waveform.

- For the seventh test waveform, the PRF should be 10 times the receiver IF bandwidth and the pulses should not be dithered but the waveform should be modulated with the type of modulation that is closest to that used for the desired signal (e.g., on-off keying for amplitude modulated signals and pulse position modulation for frequency modulated signals). This type of interfering signal will result in a modulated signal in the IF passband and the receiver should be tuned for a maximum impact from the UWB waveform.

7.0 TEST SET-UP

The standard test set-up is shown below (Figure 2). It is patterned after a similar one used in the previous Rockwell Collins UWB RFI tests on civil aviation GPS receivers done under FAA contract.

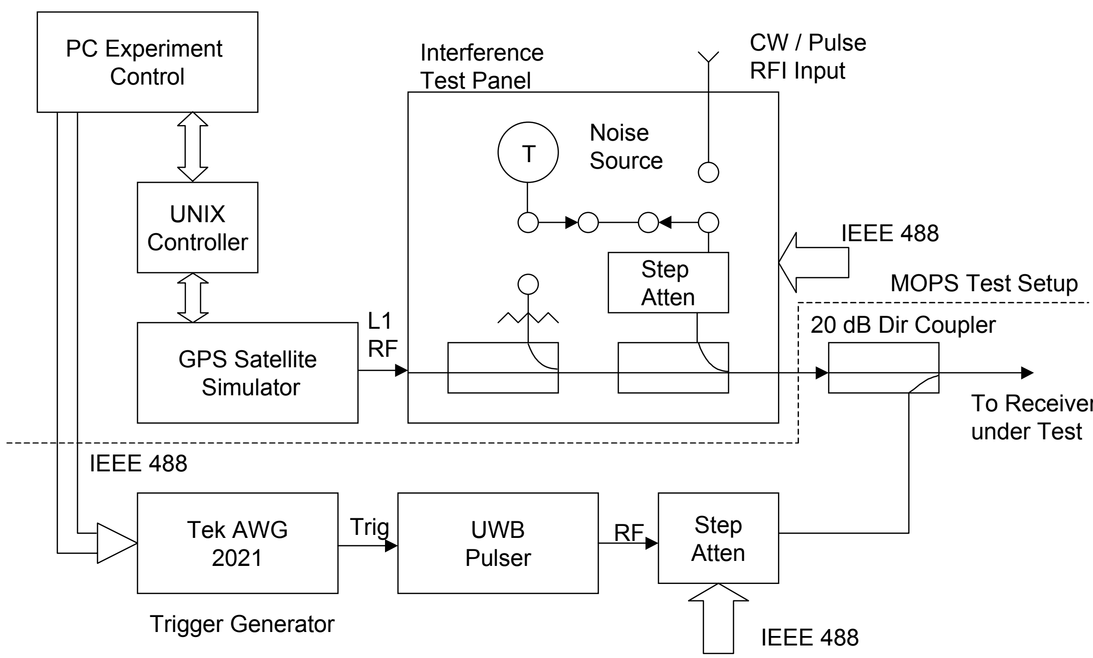

Figure 2. Test Set-Up

7.1 SINGLE UWB SUSCEPTIBILITY TESTS

7.1.1 PLGR TEST 1 - C/A-CODE MODE - TIME TO FIRST FIX TEST

7.1.1.1 Objective and Rationale

The objective of this test is to determine the susceptibility of the C/A-code TTFF to UWB EMI for the PLGR. This test is motivated by legacy military which acquire GPS satellites using the C/A-code and performing a C/A to P-code handover. The receiver will be provided with a current almanac and initialized to within 10 km of its true position based on the simulator scenario. However, ephemeris data will need to be gathered from the navigation download data from each satellite. The standard interference type used for the interference substitution approach is a CW signal at L1+0.4 MHz, with a specified level of intentional broadband noise jamming. This is an entirely new susceptibility test for the PLGR.

7.1.1.2 Test Set-Up

The test set-up diagram for the receiver sensitivity test is shown in Figure 2. A CW signal is used as the standard interference signal, and intentional broadband noise jamming will also be present during the susceptibility data collection runs.

7.1.1.3 Test Procedure for PLGR Test 1

The general test procedure for determining C/A-code TTFF susceptibility is as follows:

1. Determine the TTFF baseline standard interference (using a CW tone at the specified frequency) curve. One measurement data set is collected with essentially no added noise in order to determine observe receiver-only noise performance. Multiple data sets are collected at interference power levels that are from 5 dB below to 1 dB above the specified TTFF performance threshold of XX seconds.

2. Reduce standard interferer power 2 dB (first back-off level) from the level at which the TTFF met the specified performance threshold and replace with UWB power until threshold is achieved. Record the UWB power level that causes the threshold to be met. In practice, multiple UWB power levels may need to be tried to determine precisely when the threshold is achieved.

3. Reduce standard interferer power 4 dB (second back-off level) from the level at which the TTFF met the specified performance threshold and replace with UWB power until threshold is achieved. Record the UWB power level that causes the threshold to be met. In practice, multiple UWB power levels may need to be tried to determine precisely when the threshold is achieved.

4. Remove all standard interferer power (third back-off level) and replace with UWB power until threshold is achieved. Record the UWB power level that causes the threshold to be met. In practice, multiple UWB power levels may need to be tried to determine precisely when the threshold is achieved.

5. Repeat Steps 2 and 4 for all the candidate UWB waveforms.

7.1.1.4 Test Output

The required results from this test consist of documenting the following. All the input standard interferer power levels and resulting TTFF values must be documented in order to verify that the receiver is functioning properly and to establish the baseline interference performance. Also, the UWB power level added for each of the three back-off levels must be recorded for every UWB waveform that was tested.

7.1.2 PLGR TEST 2 - P-CODE MODE - POSITION AND SIGNAL STRENGTH TEST

7.1.2.1 Objective and Rationale

The objective of this test is to determine the susceptibility of steady state P/Y-code tracking performance to UWB EMI for the PLGR. This test is entirely new for the PLGR since it currently is not tested for conducted susceptibility at the antenna port input. For this test the standard interference type used for the interference substitution approach is a CW signal at L1+0.4 MHz, with a specified level of intentional broadband noise jamming. The receiver will be commanded to the navigation mode and allow to track in steady state for a specified period of time. Position error and C/N_0 levels are monitored in order to determine the impact of the UWB EMI.

7.1.2.2 Test Set-Up

The test set-up diagram for the receiver sensitivity test is shown in Figure 2. A CW signal is used as the standard interference signal, and intentional broadband noise jamming will also be present during the susceptibility data collection runs.

7.1.2.3 Test Procedure for PLGR Test 2

The general test procedure for determining P/Y-code steady state tracking susceptibility is as follows:

1. Determine the reacquisition baseline standard interference (using a CW tone at the specified frequency) curve. One measurement data set is collected with essentially no added noise in order to determine observe receiver-only noise performance. Multiple data sets are collected at interference power levels that are from 5 dB below to 1 dB above the specified position and C/N_0 performance thresholds of 12 meters and +/- 2 dB.

2. Reduce standard interferer power 2 dB (first back-off level) from the level at which the TTFF met the specified performance threshold and replace with UWB power until one of the thresholds is achieved. Record the UWB power level that causes the threshold to be met. In practice, multiple UWB power levels may need to be tried to determine precisely when the threshold is achieved.

3. Reduce standard interferer power 4 dB (second back-off level) from the level at which the TTFF met the specified performance threshold and replace with UWB power until one of the thresholds is achieved. Record the UWB power level that causes the threshold to be met. In practice, multiple UWB power levels may need to be tried to determine precisely when the threshold is achieved.

4. Remove all standard interferer power (third back-off level) and replace with UWB power until one of the thresholds is achieved. Record the UWB power level that causes the threshold to be met. In practice, multiple UWB power levels may need to be tried to determine precisely when the threshold is achieved.

5. Repeat Steps 2 and 4 for all the candidate UWB waveforms.

7.1.2.4 Test Output

The required results from this test consist of documenting the following. All the input standard interferer power levels and resulting reacquisition values must be documented in order to verify that the receiver is functioning properly and to establish the baseline interference performance. Also, the UWB power level added for each of the three back-off levels must be recorded for every UWB waveform that was tested.

7.1.3 PLGR TEST 3 - P-CODE MODE - DIRECT-P REAQUISITION TEST

7.1.3.1 Objective and Rationale

The objective of this test is to determine the susceptibility of the Direct P/Y-code reacquisition performance to UWB EMI for the PLGR. This test is motivated by legacy military that attempt Direct-P/Y reacquisition for relatively short signal outages, i.e., less than 1 hour. The receiver will be commanded to the navigation mode and allow to track in steady state for a specified period of time. All the satellite signals will then be blocked for a short period of time and then reacquisition performance will be determined. The standard interference type used for the interference substitution approach is a CW signal at L1+0.4 MHz, with a specified level of intentional broadband noise jamming. This is an entirely new susceptibility test for the PLGR.

7.1.3.2 Test Set-Up

The test set-up diagram for the receiver sensitivity test is shown in Figure 2. A CW signal is used as the standard interference signal, and intentional broadband noise jamming will also be present during the susceptibility data collection runs.

7.1.3.3 Test Procedure for PLGR Test 3

The general test procedure for determining Direct-P/Y reacquisition susceptibility is as follows:

1. Determine the reacquisition baseline standard interference (using a CW tone at the specified frequency) curve. One measurement data set is collected with essentially no added noise in order to determine observe receiver-only noise performance. Multiple data sets are collected at interference power levels that are from 5 dB below to 1 dB above the specified reacquisition performance threshold of XX seconds.

2. Reduce standard interferer power 2 dB (first back-off level) from the level at which the TTFF met the specified performance threshold and replace with UWB power until threshold is achieved. Record the UWB power level that causes the threshold to be met. In practice, multiple UWB power levels may need to be tried to determine precisely when the threshold is achieved.

3. Reduce standard interferer power 4 dB (second back-off level) from the level at which the TTFF met the specified performance threshold and replace with UWB power until threshold is achieved. Record the UWB power level that causes the threshold to be met. In practice, multiple UWB power levels may need to be tried to determine precisely when the threshold is achieved.

4. Remove all standard interferer power (third back-off level) and replace with UWB power until threshold is achieved. Record the UWB power level that causes the threshold to be met. In practice, multiple UWB power levels may need to be tried to determine precisely when the threshold is achieved.

5. Repeat Steps 2 and 4 for all the candidate UWB waveforms.

7.1.3.4 Test Output

The required results from this test consist of documenting the following. All the input standard interferer power levels and resulting reacquisition values must be documented in order to verify that the receiver is functioning properly and to establish the baseline interference performance. Also, the UWB power level added for each of the three back-off levels must be recorded for every UWB waveform that was tested.

7.1.4 PLGR TEST 4 - C/A-CODE MODE - POSITION AND SIGNAL STRENGTH TEST (OPTIONAL)

7.1.4.1 Objective and Rationale

The objective of this test is to determine the susceptibility of steady state C/A-code tracking performance to UWB EMI for the PLGR. This test is optional since the military utility of C/A-code steady state tracking is not as great as the P-code tracking mode. This test is entirely new for the PLGR since it currently is not tested for conducted susceptibility at the antenna port input. For this test the standard interference type used for the interference substitution approach is a CW signal at L1+0.4 MHz, with a specified level of intentional broadband noise jamming. The receiver will be commanded to the navigation mode and allow to track in steady state for a specified period of time. Position error and C/N_0 levels are monitored in order to determine the impact of the UWB EMI.

7.1.4.2 Test Set-Up

The test set-up diagram for the receiver sensitivity test is shown in Figure 2. A CW signal is used as the standard interference signal, and intentional broadband noise jamming will also be present during the susceptibility data collection runs.

7.1.4.3 Test Procedure for PLGR Test 4

The general test procedure for determining C/A-code steady state tracking susceptibility is as follows:

1. Determine the reacquisition baseline standard interference (using a CW tone at the specified frequency) curve. One measurement data set is collected with essentially no added noise in order to determine observe receiver-only noise performance. Multiple data sets are collected at interference power levels that are from 5 dB below to 1 dB above the specified position and C/N_0 performance thresholds of 12 meters and +/- 2 dB.

2. Reduce standard interferer power 2 dB (first back-off level) from the level at which the TTFF met the specified performance threshold and replace with UWB power until one of the thresholds is achieved. Record the UWB power level that causes the threshold to be met. In practice, multiple UWB power levels may need to be tried to determine precisely when the threshold is achieved.

3. Reduce standard interferer power 4 dB (second back-off level) from the level at which the TTFF met the specified performance threshold and replace with UWB power until one of the thresholds is achieved. Record the UWB power level that causes the threshold to be met. In practice, multiple UWB power levels may need to be tried to determine precisely when the threshold is achieved.

4. Remove all standard interferer power (third back-off level) and replace with UWB power until one of the thresholds is achieved. Record the UWB power level that causes the threshold to be met. In practice, multiple UWB power levels may need to be tried to determine precisely when the threshold is achieved.

5. Repeat Steps 2 and 4 for all the candidate UWB waveforms.

7.1.4.4 Test Output

The required results from this test consist of documenting the following. All the input standard interferer power levels and resulting reacquisition values must be documented in order to verify that the receiver is functioning properly and to establish the baseline interference performance. Also, the UWB power level added for each of the three back-off levels must be recorded for every UWB waveform that was tested.

7.2 MULTIPLE UWB SUSCEPTIBILITY TESTS

TBA

IV. GPS ANTENNA CHARACTERIZATION TESTS

TBA

AN/PSN-11 (PLGR) DATA SHEET

Receiver: AN/PSN-11
Frequency Band: GPS L1 (1575.42 MHz)
Receiver Mode: C/A-code mode
Standard Interference Signal: Broadband noise
Standard Response Criterion: XX second TTFF
Desired Signal Modulation: GPS C/A-code signals

APPENDIX F
UWB EMI TEST PLAN FOR THE AN/ASN-163 MINIATURE AIRBORNE GPS RECEIVER (MAGR)

1.0 INTRODUCTION

The AN/ASN-163 (MAGR) is a 5-channel airborne, military GPS receiver.

2.0 OVERALL TEST OBJECTIVE

The overall objective of the test is to determine the RFI susceptibility of the primary operational modes of the MAGR to conducted UWB signals that are injected into the receiver antenna port. The results of this investigation will provide the information necessary to evaluate the potential for UWB signals to interfere with the MAGR and to understand how UWB systems could be implemented to make use of their unique capabilities without causing EMI.

3.0 TEST APPROACH

In order to accomplish the test objective, there are several performance metrics that must be measured, each of which corresponds to a major operational mode of the receiver. These metrics are the pseudorange (PR) standard deviation for both C/A-code and P-code tracking, the Time to First Fix (TTFF) for C/A-code acquisition (includes C/A to P handover), the time for Direct P/Y reacquisition, and the position accuracy and/or signal strength susceptibility for steady-state P-code tracking. For each metric, an interference substitution approach will be used to collect the relevant test data.

Only L1 susceptibility testing will be performed, because the performance impact to L2 would be equivalent when differences in satellite power levels and in-band interference components are accounted for.

4.0 INTERFERENCE SUBSTITUTION TEST METHODOLOGY

The interference substitution test method is illustrated in Figure 1. The method for NETEX military GPS receiver testing is adapted from one developed by RTCA SC-159 for use in the civil aviation GPS receiver tests with UWB RFI. It first establishes the baseline receiver performance against a standard interference source (e.g., broadband noise in Fig. 1), then known portions of the standard interference power are removed and replaced by measured amounts of UWB interference to give the same performance. Comparison of the amounts of UWB power added with the amounts of standard RFI source power removed yield a power equivalence factor for the particular UWB waveform in the test in terms of equal RFI effect with the standard RFI source. This equivalence factor is useful in subsequent scenario analysis and receiver effect diagnosis.

The standard RFI source for the PR tests is broadband noise in similarity to the previous interference tests that were performed on commercial aviation grade GPS receivers. The standard RFI source for the acquisition, reacquisition, and position error/signal strength tests is narrowband interference, i.e., a CW tone at a fixed frequency in the GPS passband, in similarity to legacy MAGR, conducted susceptibility tests. For these latter three tests a broadband noise interference signal is also used, again in similarity to legacy conducted susceptibility tests, but this noise will not be considered part of the standard RFI source against which the UWB interference is compared.

For consistency with the NETEX RFI tests on other receivers, an additional test condition is used. In that case, no standard RFI source power is injected and the UWB power for the i^{th} mode (Uix) is determined which causes the full RFI effect (red curve in Fig. 1). For completeness, the underlying base receiver noise (Nrx) added to the UWB power is also determined.

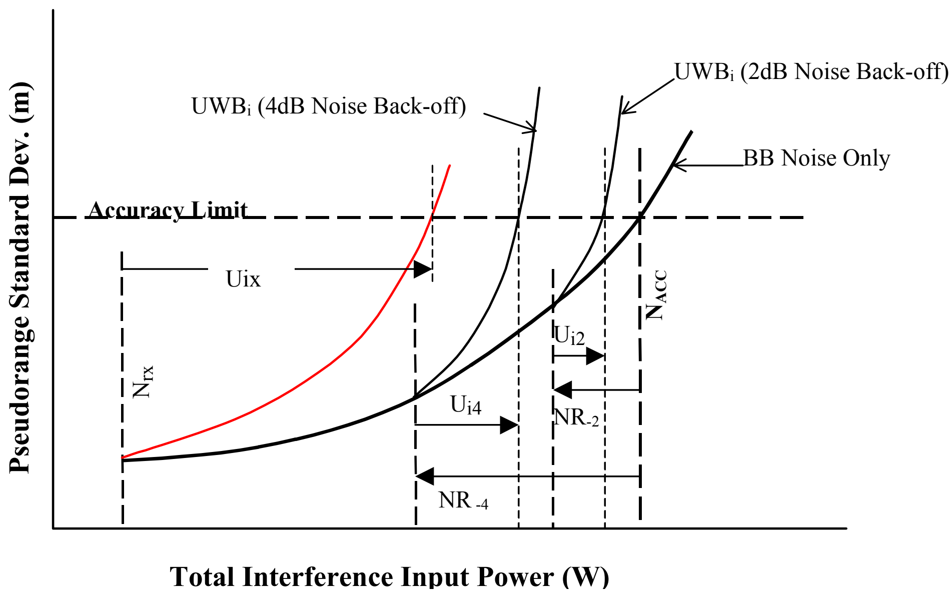

Figure 1. Graphical depiction of Interference Substitution Method for Pseudorange Standard deviation where Broadband Noise is the Standard Interference Signal.

5.0 SIMULATED SATELLITE CONSTELLATION

A multiple channel satellite simulator will be used in conducting all the GPS receiver tests. This provides a more realistic test scenario because the effects on multiple PRN codes can be evaluated. This is of particular importance for C/A-code PR test. The same satellite constellation scenario will be utilized for the C/A-code and P-code PR tests, where satellite PRN dependent effects are most likely to be exhibited. Another satellite constellation scenario may be used for the other three tests.

For the C/A-code and P-code PR tests the satellite power into the receiver will be -151 dBW. However, for the P-code PR test, the level of standard interference noise will be 3 dB greater to compensate for the 3 dB lower power, relative to C/A-code, that is transmitted by the GPS satellites. For all the other tests the satellite signal power will be set such that the receiver C/N_0 will be about 40 dB-Hz in the absence of any externally injected broadband or narrowband noise.

6.0 UWB WAVEFORMS

The UWB waveform parameters that will be used for all of the MAGR tests are as follows:

- 1.0 MHz uniform PRF
- 1.994 MHz uniform PRF
- 10.0 MHz uniform PRF
- 19.94 MHz uniform PRF, 100% duty cycle
- 20.0 MHz uniform PRF
- 15.91 MHz nominal PRF, 2 position PPM dithered
- 15.94 MHz nominal PRF, 2 position PPM dithered
- 1.994 MHz nominal PRF, 10 position PPM dithered
- 2.0 MHz nominal PRF, 10 position PPM dithered
- Gold code modulated doublet, 57.08 kHz PRF, continuous (i.e., 100% duty cycle)
- Gold code modulated doublet, 57.08 kHz PRF, 30% duty cycle (17.124 kHz effective PRF), optional
- Gold code modulated doublet, 57.08 kHz PRF, 1% duty cycle (0.5708 kHz effective PRF), optional
- MSSI custom waveform, fixed 23 bit preamble followed by pseudorandom data stream of 4096 bits at 200 MHz
- 19.94 MHz uniform PRF, 50% duty cycle, optional

7.0 TEST SET-UP

The standard test set-up is shown below (Figure 2). It is patterned after a similar one used in the previous Rockwell Collins UWB RFI tests on civil aviation GPS receivers done under FAA contract. The receiver Unit Under Test (UUT) is the MAGR. Note that the RF signal generator is not used for the two PR tests, but it is used for the other three MAGR tests. However, the 10 dB coupler remains in the set-up in order to maintain consistent input noise levels. The RF signal generator is also not used for the MAGR Validation Measurements Procedure. Detailed information on the calibration of the test set-up is provided in Attachment A of this appendix.

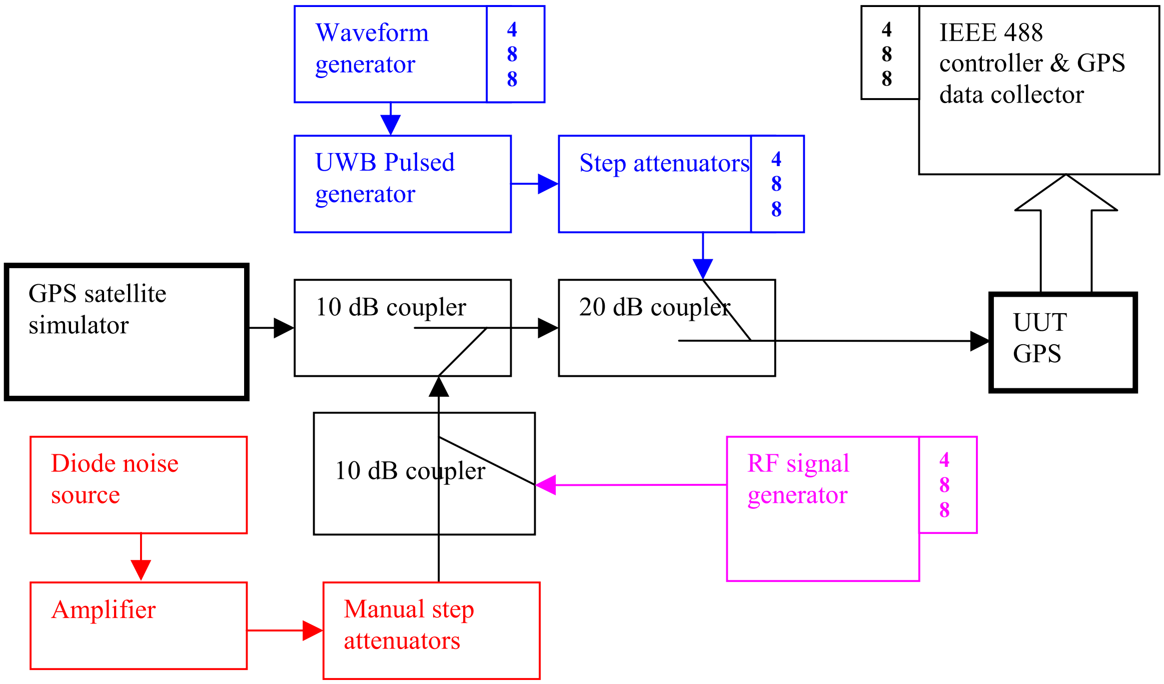

Figure 2. Test Set-Up

7.0.1 Validation Measurements for the MAGR

In addition to the proper calibration of the various components of the test set-up, validation measurements of the MAGR are to be performed to validate the receiver's proper performance and operation. The object of this test is to compute the MAGR's noise temperature and implementation loss.

7.0.2 MAGR Validation Measurements Procedure

1. Initiate satellite simulator scenario. Turn on, initialize and command MAGR to Navigation mode. Allow receiver to fully acquire satellites, almanac information and have FOM (Figure of Merit) reduce to 1 and TFOM (Time Figure of Merit) to 3 or less. (This step may take 15 to 20 minutes.) Use signal level of -151 dBW with no added interference or broadband noise.
2. After Step 1 is completed, record C/N_0 (Message Block 3 data) for ten minutes for the no added noise condition. The C/N_0 should be in the mid to upper 40s dB-Hz.
3. Then inject broadband noise of 3 dB above the reference sky noise level and record C/N_0 (Message Block 3 data) for ten minutes for this condition. The C/N_0 should be in the low 30s dB-Hz.
4. Stop data collection.
5. Extract C/N_0 data from recorded data file and compute the average value for each of the two ten minute intervals described above.

6. Using the computed C/N_0 values, the known GPS signal level and injected noise levels, compute the implementation loss and noise temperature of the MAGR using the following equations. Note that for the 'no added noise' condition of Step 2 the injected noise due to the test set-up is broadband noise having an equivalent noise temperature of 300°K.

$$Li = \frac{\left(S/_{CN01} - S/_{CN02} \right)}{(N1 - N2)}$$

$$Tr = 1/_k \left(\frac{S}{Li * CN01} - N1 \right)$$

where S = -151 dBW, k is Boltzmann's constant, CN01 is the computed C/N_0 for the 'no added noise' case (i.e., N1 = k*300°K), and CN02 is the computed C/N_0 for the 'added noise' case (N2 determined by setup calibration).

Li = 1.2 dB and Tr = 700°K are typical values for a MAGR.

7.1 MAGR TEST 1 - C/A-CODE MODE - PSEUDORANGE (PR) STD. DEV. TEST

7.1.1 Objective and Rationale

The objective of this test is to determine the susceptibility of the PR measurement standard deviation to UWB EMI for the MAGR when operating in C/A-code tracking mode. This test is motivated by military aircraft operation in civil airspace. Military receiver compatibility with civil certification and operational requirements may require C/A-code operation for all phases of flight, including precision approach and landing, when operating in civil airspace. The unsmoothed pseudorange measurement is the performance metric of interest for this test and the standard interference type used for the interference substitution approach is broadband noise. This test is very similar to the UWB interference testing performed on a Collins MMR under an FAA contract [ref 1].

7.1.2 Test Set-Up

The test set-up diagram for the receiver sensitivity test is shown in Figure 2. Broadband noise is used as the standard interference signal. The RF signal generator for CW interference is not used for this test.

7.1.3 Test Procedure for MAGR Test 1

The general test procedure for determining C/A-code PR measurement susceptibility is as follows:

25. Initiate satellite simulator scenario. Turn on, initialize and command MAGR to Navigation mode. Allow receiver to fully acquire satellites, almanac information and have FOM (Figure of Merit) reduce to 1 and TFOM (Time Figure of Merit) to 3 or less to achieve steady-state tracking condition. (This step may take 15 to 20 minutes.) Use a GPS signal level of -151 dBW with no added UWB interference or broadband noise. (The MAGR should have been powered up for at least 15 minutes before the following steps are conducted.) Throughout the following steps the operator should frequently verify that the receiver is navigating properly. If not, the receiver should be reinitialized to the correct navigation state.

26. Establish and verify the pseudorange (unsmoothed) baseline performance threshold of **2.80 m (1-sigma)** for the standard RFI (broadband noise) level. Using a GPS signal level of -151 dBW, add in the standard RFI and collect 5 minute intervals of PR, DR and C/N_0 data (Blocks 3 and 1331) at 5 levels about the standard RFI level of **3 dB** above the background sky noise reference. The five different noise levels should be in 1 dB increments from 1 dB above sky noise to 5 dB above sky noise. The data should be post processed to determine the interference noise level that provides a PR 1-sigma noise that is closest to 2.80 m. This noise level will be used as the standard RFI level for the subsequent data collection steps.

27. Collect one five-minute interval of PR, DR and C/N_0 data (Blocks 3 and 1331) with the standard RFI level as determined in Step 2. Reduce standard interferer power 2 dB (first back-off level) from the standard RFI level and replace with UWB power until threshold is achieved. Record the UWB power level that causes the threshold to be met. In practice, at least three UWB power levels each spaced by 3 dB attenuator steps may need to be tried to determine precisely where the threshold is achieved. The C/N_0 reading from the receiver is used to determine the likely UWB attenuator settings, since C/N_0 provides the best observable, though indirect, indication of PR measurement noise.

28. Reduce standard interferer power 4 dB (second back-off level) from the standard RFI level and replace with UWB power until threshold is achieved. Record the UWB power level that causes the threshold to be met. In practice, at least three UWB power levels each spaced by 2 dB attenuator steps may need to be tried to determine precisely where the threshold is achieved. The C/N_0 reading from the receiver is used to determine the likely UWB attenuator settings, since C/N_0 provides the best observable, though indirect, indication of PR measurement noise.

29. Remove all standard interferer power (third back-off level) and replace with UWB power until threshold is achieved. Record the UWB power level that causes the threshold to be met. In practice, at least three UWB power levels each spaced by 2 dB attenuator steps may need to be tried to determine precisely where the threshold is achieved. The C/N_0 reading from the receiver is used to

determine the likely UWB attenuator settings, since C/N_0 provides the best observable, though indirect, indication of PR measurement noise.

30. Repeat steps 3 through 5 for all the candidate UWB waveforms.

31. Post-process the data to determine the UWB attenuator settings at which the PR performance threshold is achieved for each back-off level and each UWB waveform. Standard RFI equivalency factors relative to the standard RFI for each UWB waveform can then be computed and documented.

Refer to Attachment A of this appendix for a more detailed description of the steps necessary to properly conduct the tests and record the data. Details of the post-processing steps are also provided in the attachment.

7.1.4 Test Output

The required results from this test consist of documenting the following. All the input standard interferer power levels and resulting PR standard deviation values must be documented in order to verify that the receiver is functioning properly and to establish the baseline interference performance. Also, the UWB power level added for each of the three back-off levels must be recorded for every UWB waveform that was tested.

7.2 MAGR TEST 2 (OPTIONAL)- C/A-CODE MODE - TIME TO FIRST FIX TEST

7.2.1 Objective and Rationale

The objective of this test is to determine the susceptibility of TTFF to UWB EMI for the MAGR. This test is motivated by legacy military which acquire GPS satellites using the C/A-code and performing a C/A to P-code handover. The receiver will be provided with a current almanac and initialized to within 10 km of its true position based on the simulator scenario. However, ephemeris data will need to be gathered from the navigation download data from each satellite. The standard interference type used for the interference substitution approach is a specified level of broadband noise. This is an entirely new susceptibility test for the MAGR.

7.2.2 Test Set-Up

The test set-up diagram for the receiver sensitivity test is shown in Figure 2. The RF signal generator is not used. The broadband noise will be used as the standard interference signal during the susceptibility data collection runs.

7.2.3 Test Procedure for MAGR Test 2

The general test procedure for determining TTFF susceptibility is as follows:

1. Initiate satellite simulator scenario. Turn on, initialize and command MAGR to Navigation mode. Allow receiver to fully acquire satellites, almanac information and have FOM (Figure of Merit) reduce to 1 and TFOM (Time Figure of Merit) to 3 or less to achieve steady-state tracking condition. (This step may take 15 to 20 minutes.) Use a GPS signal level of -151 dBW with no added UWB interference or broadband noise. (The MAGR should have been powered up for at least 15 minutes before the following steps are conducted.) Throughout the following steps the operator should frequently verify that the receiver is navigating properly. If not, the receiver should be reinitialized to the correct navigation state.

2. Establish and verify the TTFF baseline performance threshold of XX seconds for the standard RFI level. Using a GPS signal level which provides a C/N_0 of 40 dB-Hz with no added noise (about -160 dBW), add broadband noise to provide a C/N_0 of 28 dB-Hz (YY dBm of broadband noise). Collect 10 TTFF trials of Nav Invalid data (from Block 3) at each of 5 levels about the broadband noise of YY dBm. The five different noise levels should be in 1 dB increments from YY dBm plus 2 dB to YY dBm minus 2 dB. The data should be post processed to determine the interference noise level that provides an average TTFF that is closest to XX seconds. This noise level will be used as the standard RFI level for the subsequent data collection steps.

3. Collect 10 TTFF trials of Nav Invalid data (from Block 3) with the standard RFI level as determined in Step 2. (The GPS signal level should be as described in the previous step to provide a 40 dB-Hz C/N_0 in the absence of the standard RFI.) Reduce standard interferer power 2 dB (first back-off level) from the standard RFI level and replace with UWB power until TTFF performance threshold is achieved. Record the UWB power level that causes the threshold to be met, collecting 10 TTFF trials of Nav Invalid data at each RFI level. In practice, at least three UWB power levels each spaced by 3 dB attenuator steps may need to be tried to determine precisely where the threshold is achieved. A number of preliminary TTFF trials will need to be conducted in order to determine the approximate range of the UWB attenuator settings.

4. Reduce standard interferer power 4 dB (second back-off level) from the standard RFI level and replace with UWB power until threshold is achieved. Record the UWB power level that causes the threshold to be met, collecting 10 TTFF trials of Nav Invalid data at each RFI level. In practice, at least three UWB power levels each spaced by 2 dB attenuator steps may need to be tried to determine precisely where the threshold is achieved. A number of preliminary TTFF trials will need to be conducted in order to determine the approximate range of the UWB attenuator settings.

5. Remove all standard interferer power (third back-off level) and replace with UWB power until TTFF threshold is achieved. Record the UWB power level that causes the threshold to be met, collecting 10 TTFF trials of Nav Invalid data at

each RFI level. In practice, at least three UWB power levels each spaced by 2 dB attenuator steps may need to be tried to determine precisely where the threshold is achieved. A number of preliminary TTFF trials will need to be conducted in order to determine the approximate range of the UWB attenuator settings.

6. Repeat steps 3 through 5 for all the candidate UWB waveforms.

7. Post-process the data to determine the UWB attenuator settings at which the average TTFF performance threshold is achieved for each back-off level and each UWB waveform. Standard RFI equivalency factors relative to the standard RFI for each UWB waveform can then be computed and documented.

Refer to Attachment A of this appendix for a more detailed description of the steps necessary to properly conduct the tests and record the data. Details of the post-processing steps are also provided in the attachment.

7.2.4 Test Output

The required results from this test consist of documenting the following. All the input standard interferer power levels and resulting average TTFF values must be documented in order to verify that the receiver is functioning properly and to establish the baseline interference performance. Also, the UWB power level added for each of the three back-off levels must be recorded for every UWB waveform that was tested.

7.3 MAGR TEST 3 - P-CODE MODE - PSEUDORANGE STD. DEV. TEST

7.3.1 Objective and Rationale

The objective of this test is to determine the susceptibility of the PR measurement standard deviation to UWB EMI for the MAGR when operating in P-code tracking mode. This test is motivated by precision approach and landing during military operations. The unsmoothed pseudorange measurement is the performance metric of interest for this test and the standard interference type used for the interference substitution approach is broadband noise. This test is very similar to MAGR Test 1 except that P-code tracking is used in this test.

7.3.2 Test Set-Up

The test set-up diagram for the receiver sensitivity test is shown in Figure 2. Broadband noise is used as the standard interference signal. The RF signal generator for CW interference is **not** used for this test.

7.3.3 Test Procedure for MAGR Test 3

The general test procedure for determining P-code PR measurement susceptibility is as follows:

1. Initiate satellite simulator scenario. Turn on, initialize and command MAGR to Navigation mode. Allow receiver to fully acquire satellites, almanac information and have FOM (Figure of Merit) reduce to 1 and TFOM (Time Figure of Merit) to 3 or less to achieve steady-state tracking condition. (This step may take 15 to 20 minutes.) Use a GPS signal level of -151 dBW with no added interference or broadband noise. (The MAGR should have been powered up for at least 15 minutes before the following steps are conducted.) Throughout the following steps the operator should frequently verify that the receiver is navigating properly. If not, the receiver should be reinitialized to the correct navigation state.

2. Establish and verify the pseudorange (unsmoothed) baseline performance threshold of **0.4 m (1-sigma)** for the standard RFI (broadband noise) level. Using a GPS signal level of -151 dBW, add in the standard RFI and collect 5 minute intervals of PR, DR and C/N_0 data (Blocks 3 and 1331) at 5 levels about the standard RFI level of **6 dB** above the background sky noise reference. The five different noise levels should be in 1 dB increments from 4 dB above sky noise to 8 dB above sky noise. The data should be post processed to determine the interference noise level that provides a PR 1-sigma noise that is closest to **0.4 m**. This noise level will be used as the standard RFI level for the subsequent data collection steps.

3. Collect one five-minute interval of PR, DR and C/N_0 data (Blocks 3 and 1331) with the standard RFI level as determined in Step 2. Reduce standard interferer power 2 dB (first back-off level) from the standard RFI level and replace with UWB power until threshold is achieved. Record the UWB power level that causes the threshold to be met. In practice, at least three UWB power levels each spaced by 3 dB attenuator steps may need to be tried to determine precisely where the threshold is achieved. The C/N_0 reading from the receiver is used to determine the likely UWB attenuator settings, since C/N_0 provides the best observable, though indirect, indication of PR measurement noise.

4. Reduce standard interferer power 4 dB (second back-off level) from the standard RFI level and replace with UWB power until threshold is achieved. Record the UWB power level that causes the threshold to be met. In practice, at least three UWB power levels each spaced by 2 dB attenuator steps may need to be tried to determine precisely where the threshold is achieved. C/N_0 reading from the receiver is used to determine the likely UWB attenuator settings, since C/N_0 provides the best observable, though indirect, indication of PR measurement noise.

5. Remove all standard interferer power (third back-off level) and replace with UWB power until threshold is achieved. Record the UWB power level that causes the threshold to be met. In practice, at least three UWB power levels each spaced by 2 dB attenuator steps may need to be tried to determine precisely where the threshold is achieved. C/N_0 reading from the receiver is used to determine the

likely UWB attenuator settings, since C/N_0 provides the best observable, though indirect, indication of PR measurement noise.

6. Repeat steps 3 through 5 for all the candidate UWB waveforms.

7. Post-process the data to determine the UWB attenuator settings at which the PR performance threshold is achieved for each back-off level and each UWB waveform. Standard RFI equivalency factors relative to the standard RFI for each UWB waveform can then be computed and documented.

Refer to Attachment A of this appendix for a more detailed description of the steps necessary to properly conduct the tests and record the data. Details of the post-processing steps are also provided in the attachment.

7.3.4 Test Output

The required results from this test consist of documenting the following. All the input standard interferer power levels and resulting PR standard deviation values must be documented in order to verify that the receiver is functioning properly and to establish the baseline interference performance. Also, the UWB power level added for each of the three back-off levels must be recorded for every UWB waveform that was tested.

7.4 MAGR TEST 4 - P-CODE MODE - DIRECT-P REAQUISITION TEST

7.4.1 Objective and Rationale

The objective of this test is to determine the susceptibility of the Direct P/Y-code reacquisition performance to UWB EMI for the MAGR. This test is motivated by legacy military systems that attempt Direct-P/Y reacquisition for relatively short signal outages, (i.e., less than 20 seconds). The receiver will be commanded to the navigation mode and allowed to track in steady state for a specified period of time. Some of the satellite signals will then be blocked (i.e., greatly attenuated) for no more then 10 seconds and then reacquisition performance will be determined. The standard interference type used for the interference substitution approach is a specified level of broadband noise. This is an entirely new susceptibility test for the MAGR.

For the MAGR to perform a direct P-L1 reacquisition, the receiver must be in a Jammed condition. The receiver must initially be tracking L1 in State 5 on all channels. L2 signals must not be available. The MAGR must continue to track in State 5 on at least 2 primary channels when the jammed satellite signals are blocked. The minimum J/S on the unjammed primary channels must be greater than 36 dB. Note that if all satellite signals are lost, the receiver does not consider itself jammed and will attempt reacquisition strategies other than a direct P code reacquisition.

7.4.2 Test Set-Up

The test set-up diagram for the receiver sensitivity test is shown in Figure 2. The RF signal generator is not used. Broadband noise will be used as the standard interference signal during the susceptibility data collection runs.

7.4.3 Test Procedure for MAGR Test 4

The general test procedure for determining Direct-P/Y reacquisition susceptibility is as follows:

1. Initiate satellite simulator scenario. Turn on, initialize and command MAGR to Navigation mode. Allow receiver to fully acquire satellites, almanac information and have FOM (Figure of Merit) reduce to 1 and TFOM (Time Figure of Merit) to 3 or less to achieve steady-state tracking condition. (This step may take 15 to 20 minutes.) Use a GPS signal level of -151 dBW with no added interference or broadband noise. (The MAGR should have been powered up for at least 15 minutes before the following steps are conducted.) Throughout the following steps the operator should frequently verify that the receiver is navigating properly. If not, the receiver should be reinitialized to the correct navigation state.

2. Establish and verify the reacquisition baseline performance threshold of 15 seconds for the standard RFI level. Using a GPS signal level which provides a C/N_0 of 40 dB-Hz for no added noise (about -160 dBW), add broadband noise to provide a C/N_0 of 28 dB-Hz (YY dBm of broadband noise). Then collect 10 reacquisition trials of Nav Invalid data (from Block 3) at each of 5 levels about the broadband noise level of YY dBm. The five different noise levels should be in 1 dB increments from YY dBm plus 2 dB to YY dBm minus 2 dB. The data should be post processed to determine the interference noise level that provides an average reacquisition time that is closest to 15 seconds. This noise level will be used as the standard RFI level for the subsequent data collection steps.

3. Collect 10 reacquisition trials of Nav Invalid data (from Block 3) with the standard RFI level as determined in Step 2. The GPS signal level should be as described in the previous step to provide a 40 dB-Hz C/N_0 in the absence of the standard RFI. Reduce standard interferer power 2 dB (first back-off level) from the standard RFI level and replace with UWB power until reacquisition performance threshold is achieved. Record the UWB power level that causes the threshold to be met, collecting 10 reacquisition trials of Nav Invalid data at each RFI level. In practice, at least three UWB power levels each spaced by 3 dB attenuator steps may need to be tried to determine precisely where the threshold is achieved. A number of preliminary reacquisition trials will need to be conducted in order to determine the approximate range of the UWB attenuator settings.

4. Reduce standard interferer power 4 dB (second back-off level) from the standard RFI level and replace with UWB power until threshold is achieved. Record the UWB power level that causes the threshold to be met, collecting 10 reacquisition trials of Nav Invalid data at each RFI level. In practice, at least three UWB power

levels each spaced by 2 dB attenuator steps may need to be tried to determine precisely where the threshold is achieved. A number of preliminary reacquisition trials will need to be conducted in order to determine the approximate range of the UWB attenuator settings.

5. Remove all standard interferer power (third back-off level) and replace with UWB power until the reacquisition threshold is achieved. Record the UWB power level that causes the threshold to be met, collecting 10 reacquisition trials of Nav Invalid data at each RFI level. In practice, at least three UWB power levels each spaced by 2 dB attenuator steps may need to be tried to determine precisely where the threshold is achieved. A number of preliminary reacquisition trials will need to be conducted in order to determine the approximate range of the UWB attenuator settings.

6. Repeat steps 3 through 5 for all the candidate UWB waveforms.

7. Post-process the data to determine the UWB attenuator settings at which the average reacquisition performance threshold is achieved for each back-off level and each UWB waveform. Standard RFI equivalency factors relative to the standard RFI for each UWB waveform can then be computed and documented.

Refer to Attachment A of this appendix for a more detailed description of the steps necessary to properly conduct the tests and record the data. Details of the post-processing steps are also provided in the attachment.

7.4.4 Test Output

The required results from this test consist of documenting the following. All the input standard interferer power levels and resulting average reacquisition values must be documented in order to verify that the receiver is functioning properly and to establish the baseline interference performance. Also, the UWB power level added for each of the three back-off levels must be recorded for every UWB waveform that was tested.

7.5 MAGR TEST 5 - P-CODE MODE - POSITION ERROR AND SIGNAL STRENGTH TEST

7.5.1 Objective and Rationale

The objective of this test is to determine the susceptibility of steady state P/Y-code tracking performance to UWB EMI for the MAGR. This test is motivated by the MAGR's legacy susceptibility test. The legacy test is modified to follow the interference substitution method used for the other tests. The standard interference type used for the interference substitution approach is a CW signal at L1+0.4 MHz, with a specified level of intentional broadband noise jamming. The receiver will be commanded to the navigation mode and allowed to track in steady state for a specified period of time. Position error and C/N_0 levels are monitored in order to determine the impact of the

UWB EMI.

7.5.2 Test Set-Up

The test set-up diagram for the receiver sensitivity test is shown in Figure 2. A CW signal from the RF signal generator is used as the standard interference signal and intentional broadband noise jamming will also be present during the susceptibility data collection runs.

7.5.3 Test Procedure for MAGR Test 5

The general test procedure for determining P/Y-code steady state tracking susceptibility is as follows:

1. Initiate satellite simulator scenario. Turn on, initialize and command MAGR to Navigation mode. Allow receiver to fully acquire satellites, almanac information and have FOM (Figure of Merit) reduce to 1 and TFOM (Time Figure of Merit) to 3 or less to achieve steady-state tracking condition. (This step may take 15 to 20 minutes.) Use a GPS signal level of -151 dBW with no added interference or broadband noise. (The MAGR should have been powered up for at least 15 minutes before the following steps are conducted.) Throughout the following steps the operator should frequently verify that the receiver is navigating properly. If not, the receiver should be reinitialized to the correct navigation state.

2. Establish and verify the position and signal strength baseline performance threshold of +/- 2 dB and/or 12 m horizontal/vertical position error for the standard RFI (CW tone) level. Using a GPS signal level which provides a C/N_0 of 40 dB-Hz for no added noise (about -160 dBW), add broadband noise to provide a C/N_0 of 30 dB-Hz. Then add in the standard RFI and collect 5 minute intervals of position and C/N_0 data (Block 3) at 5 levels about the standard RFI level of YY dBm. The five different noise levels should be in 1 dB increments from YY dBm minus 2 dB to YY dBm plus 2 dB. The data should be post processed to determine the CW tone interference noise level that provides signal strength deviation and/or horizontal/vertical position error of +/- 2 dB and/or 12 m. This noise level will be used as the standard RFI level for the subsequent data collection steps.

3. Collect one five-minute interval of position and C/N_0 data (Block 3) with the standard RFI level as determined in Step 2. Reduce standard interferer power 2 dB (first back-off level) from the standard RFI level and replace with UWB power until one or both of the signal strength and position error thresholds is achieved. Record the UWB power level that causes the threshold(s) to be met. For this test, both position error and C/N_0 can be directly monitored in order to determine the UWB attenuator setting. Three 5 minute intervals of position and C/N_0 data for three different UWB attenuator settings near the threshold should be

collected for post-processing in order to establish more accurate average estimates of the position error and signal strength deviation.

4. Reduce standard interferer power 4 dB (second back-off level) from the standard RFI level and replace with UWB power until one or both of the position error and signal strength thresholds is achieved. Record the UWB power level that causes the threshold(s) to be met. Both position error and C/N_0 can be directly monitored in order to determine the UWB attenuator setting. Three 5 minute intervals of position and C/N_0 data for three different UWB attenuator settings near the threshold should be collected for post-processing in order to establish more accurate average estimates of the position error and signal strength deviation.

5. Remove all standard interferer power (third back-off level) and replace with UWB power until one or both of the thresholds is achieved. Record the UWB power level that causes the threshold(s) to be met. Both position error and C/N_0 can be directly monitored in order to determine the UWB attenuator setting. Three 5 minute intervals of position and C/N_0 data for three different UWB attenuator settings near the threshold should be collected for post-processing in order to establish more accurate average estimates of the position error and signal strength deviation.

6. Repeat steps 3 through 5 for all the candidate UWB waveforms.

7. Post-process the data to determine the UWB attenuator settings at which one or both of the performance thresholds is achieved for each back-off level and each UWB waveform. Standard RFI equivalency factors relative to the standard RFI for each UWB waveform can then be computed and documented.

Refer to Attachment A of this appendix for a more detailed description of the steps necessary to properly conduct the tests and record the data. Details of the post-processing steps are also provided in the attachment.

7.5.4 Test Output

The required results from this test consist of documenting the following. All the input standard interferer power levels and resulting signal strength and position error values must be documented in order to verify that the receiver is functioning properly and to establish the baseline interference performance. Also, the UWB power level added for each of the three back-off levels must be recorded for every UWB waveform that was tested.

APPENDIX F
Attachment A

MAGR Detailed Test and Post-Processing Procedure

OVERVIEW

The unit under test is a Collins MAGR GPS receiver. The GPS signal source is a Collins PCSG satellite simulator. The GPS signal standard interference sources are broadband noise or a CW RF signal. An Ultra-wide Band generator from MSSI is to generate various UWB waveforms whose interference effects on the MAGR are to be quantified.

1.0 TEST HARDWARE SETUP AND TEST EQUIPMENT

The following table lists the test equipment used for this procedure.

Name/description	**Mfg/model**	**note**
UWB generator	MSSI BFP1000	NETEX GFE
Step RF attenuators & controller	HP 11713A driver, 8494H & 8496H attenuators	DC-18GHz, 1 & 10 dB steps
Manual RF step attenuators	Agilent 8494A & 8496A	1 & 10 dB steps
Directional couplers	Narda 3042B-10	10 dB, .92 to 2.2 GHz
Directional coupler	Narda 3022	20 dB, 1-4 GHz
Noise diode	HP 346B	Min 14 dB ENR
Amplifier	Mini-Circuits ZEL-1217LN	1.2 to 1.7 GHz 20 dB gain, low noise amp
Arbitrary waveform generator	TEK AWG2021-02	Dual channel with defined waveforms
GPS simulator	PCSG	Scenario- 6 satellite static, PCSG has integrated data collection
Signal generator	HP8648D	9KHz to 4 MHz range
IEEE 488 bus controller	Laptop computer with HPIB interface	Custom LabView program
DC power supplies	as needed	For diode, UWB, amp
AC power supply	400 cycle 125 V	MAGR power

The equipment is interconnected as show in Figure 1. The throughput loss for the signal paths are determined and recorded. These paths are from the UWB output coax connection to the MAGR input connector, from the GPS simulator connection to the MAGR input connector, and from the CW Signal generator output connector to the MAGR.

The noise path is calibrated in measured noise power presented at the MAGR input connector. The noise power levels for the various attenuation settings are recorded.

The UWB output power is measured at its output connector. A bandwidth limited power out is measured with a power meter and recorded for each individual trigger waveform to be used during testing. The UWB measurement filter has an 80 MHz bandwidth and a center frequency at GPS L1, 1575.4 MHz.

The PCSG controllable satellite power levels are calibrated to the end of the PCSG coax.

The recorded CW signal level is the output of the calibrated signal generator.

All of the variable attenuators are calibrated for the appropriate frequencies they control.

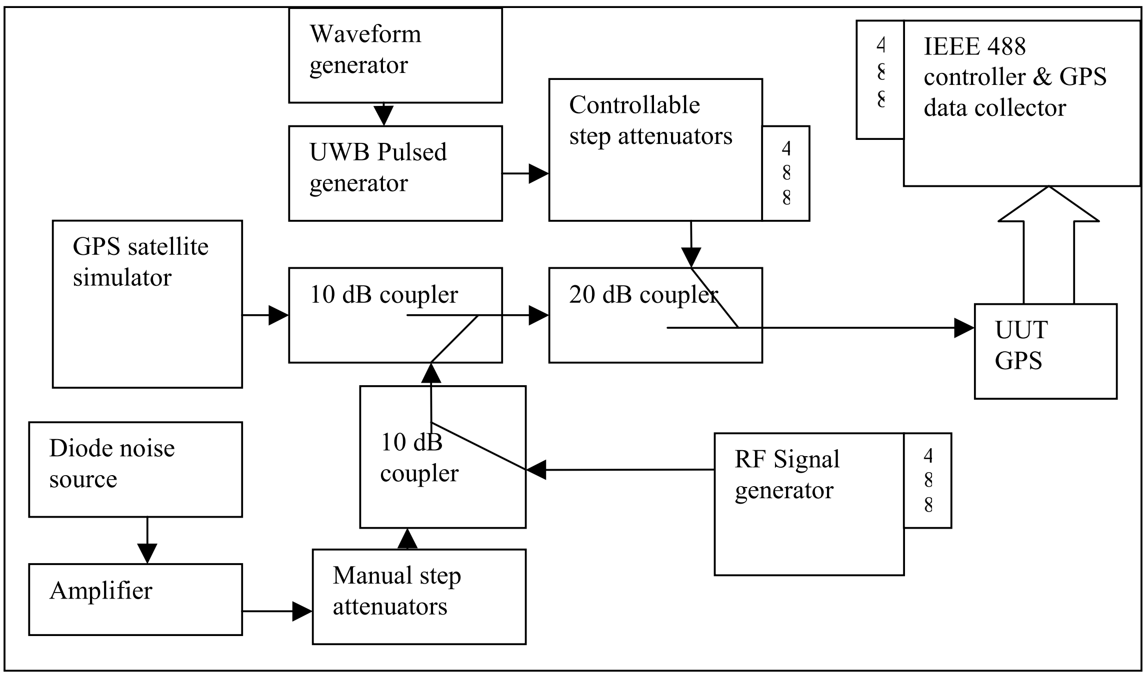

Figure 1. Test Set-Up

2.0 OPERATIONAL INFORMATION FOR MAGR GPS RECEIVER

The MAGR may use a control/display unit (CDU) to enable manual input of initialization data and user visibility of GPS performance, as in our test setup. In addition to the simulator RF connection, the MAGR is connected to the PCSG test station through the 1553 data bus to enable the downloading of the almanac information. The MAGR data logging is handled by the PCSG test station using a variant of BBCOM data logging software through an additional interconnect cable. None of the "aiding cables" are connected, ie Havequick, Baro, etc. The MAGR and CDU require 400 cycle power that is provided by a lab power panel (400 cycle power supply).

To acquire a valid position fix and track satellites, the GPS requires almanac information. Almanac can be acquired during the first 15 minutes of a scenario via information from the satellites or it can downloaded directly into the MAGR at the start of the scenario. This download is set up as a part of the scenario command file. For this testing almanac is downloaded via the 1553 bus during the first minute of each scenario. The MAGR must remain in INIT mode for the first minute of the scenario run to obtain the almanac data. If it is not powered down nor the batteries removed, the MAGR will retain the almanac data for a scenario. Once the MAGR has been loaded with the appropriate almanac after power on, the unit can be switched from INIT to NAV at the re-start of the scenario without the one minute wait.

When under CDU control, the MAGR requires the initialization of the position, date, and time to be hand loaded through the CDU. The initialization time and position are determined by the GPS simulator scenario used. After the MAGR is power up and has passed self test, enter the time and position relatively close to that of the start of the scenario simulated time and scenario position.

If using a CDU for the time and date entry, set the CDU select to TRK-GS. The time and date are in the second menu. This menu is accessed through the up/down arrow key. Select time or date with the buttons to the left of the display. The time can be entered in year and day-of-the-year, or in a MM/DD/YY format. This is selectable with the up/down key. Enter time with keypad and load with button to left of display.

For position entry, set the CDU select to POS. Position entry is the default screen. Position format is N030 or W114, for example. Select with left button, enter position information with keypad, and load with left button. The MAGR can now be switched into NAV mode.

The MAGR NAV performance is monitored via displays available in the STAT select position.

The summary of the CDU controlled MAGR initialization sequence is:
1. power on,
2. switch to INIT mode,
3. allow automatic self test to complete,
4. manually enter time/date and position information,
5. allow scenario control program to run for about 1 minute to download almanac,
6. switch MAGR to NAV mode.

3.0 OPERATIONAL INFORMATION FOR PCSG GPS SATELLITE SIMULATOR

The PCSG is the GPS satellite constellation simulator. It is controlled with computer based command files. The satellite information is provided by a software satellite "scenario" file stored on the computer and called up by the command file.

The PCSG is controllable by a defined set of commands. The command menu is not detailed as it is specified elsewhere and applicable only to this simulator. The commands are used to define the initial operating conditions at the start of a scenario run. They are also used to allow interactive changes to be made to the PCSG output characteristics while a scenario is running.

The individual command lines can be used to created command files. In the command files, the lines can be executed immediately when read, or at either a specified GPS scenario time or at some real time delay after the line has been read. The commands can control the output power of the individual satellite channels, turn the P/CA codes or L1/L2 frequencies on and off, as well as many other functions.

Sample copies of the PCSG command files that were used during testing are included at the end of this document. Although the command files may not be directly transferable to other simulators, they will show power level settings and sequencing of commands.

The following anomalies apply only to the PCSG simulator. The satellite output power is only calibrated if the master satellite control attenuator is set to 0. Each satellite's power must be individually commanded to a specified level. The command to "change all" satellite channel powers at the same time does not produce a calibrated output level. Again for the PCSG only, even with the calibrated output levels, for a defined level, the actual channel powers can be mismatched by as much as 1 dB. The satellite power command sets both the L1-P code power and the L1-CA code power to the same level.

Associated with each satellite scenario is an almanac of information that the GPS receiver uses to know which satellites are available to track. In a normal situation, almanac is downloaded from the satellites to the GPS and can take up to 15 minutes. The PCSG test station loads almanac directly into the MAGR during the first minute of a scenario via a 1553 bus.

For this testing, we have generated a custom scenario that loads keys into the MAGR and downloads MAGR formatted almanac data. The scenario has 6 visible satellites and the GPS is stationary. The scenario name is MG1005Y.idf. It has a fixed position of approximately N 033 and W114, a date of December 25, 1983 (year 83, day 359), and a scenario start time of approximately 16:50 UTC.

The PCSG computer logs the GPS output data and is controlled by the control command file. The blocks of data that are needed from the MAGR are enabled (connected) in the command file.

The MAGR output information that must be connected for this test procedure are Block 1331 and Block 3.

The PCSG control computer records the selected MAGR information blocks from the beginning of the scenario run until the run is terminated. The file name where the data is stored is specified by the command file. If a scenario is run repeatedly and the output file name is not changed, the currently logged data is appended to the data file.

To ease tracking of the data collection sets, the collected data files should be renamed or deleted after each scenario run.

4.0 OPERATIONAL INFORMATION FOR THE ULTRA WIDEBAND GENERATOR

The Ultra Wideband generator (UWB) was supplied by MSSI. Although the generator has the capability to generate various waveforms and control the UWB power level, for this testing, we supply these functions externally. The UWB pulse waveforms are triggered by signals from an arbitrary waveform generator. The UWB power is varied by use of HPIB controlled step attenuators.

The various waveforms used to trigger the UWB were generated by an arbitrary waveform generator (AWG). The waveforms were defined and permanent AWG compatible files were generated and saved to enable consistent rerunning of the waveforms. The TEK2021 AWG loses all loaded waveform data when powered down.

To produce AWG waveforms, the complex trigger data string sequences were generated in Mathcad or Excel and stored in comma separated variable text files. These text files were converted to AWG usable files using a csv2wfm.exe file obtained from the Tektronix website. An idiosyncrasy of the TEK2021 AWG is that the data file lengths must be divisible by 8.

The UWB generator requires the AWG output level to be at a magnitude of at least 4.2 Volts and a DC offset of 1 Volt. The UWB output pulse shape and power level were sensitive to AWG drive level. Even with the same drive levels, the trigger would produce different power out and RF pulse characteristics when it was switched between the positive and negative trigger inputs. The UWB power measurements used a constant trigger magnitude and offset.

The UWB power levels are individually determined for each waveform. The bandwidth limited power is measured at the UWB output.

The UWB had a time skew between the positive and negative trigger input responses. This skew was offset by varying the cable length between the AWG channel outputs and the UWB trigger inputs. These cable lengths became part of the calibrated setup.

The UWB power to the MAGR was adjusted by a calibrated set of HPIB controllable step attenuators. An automated LabView program controlled the attenuators during data collection recordings. The program allowed the UWB level control attenuators to dwell at defined attenuation levels for a fixed amount of time.

5.0 OPERATIONAL INFORMATION FOR REFERENCE INTERFERENCE SOURCES

5.1 Broadband noise

The broadband noise interference signal is generated by a noise diode. The noise is amplified by a low noise amplifier. The noise level presented to the MAGR is controlled by manually adjusted step attenuators. The level is calibrated at the input connector of the MAGR.

Due to the amplifier in the noise string, when a data collection set requires no added noise, the DC power is turned off to both the noise diode and the amplifier. Even with no input signal, the amplifier could generate a small amount of noise that might influence the data.

For our tests, a reference noise power level of 16 Pd dB is referred to. This noise power level is representative of typical sky noise projected through an ARINC 743 active antenna GPS input configuration. The ARINC 743 configuration assumes 13 dB of cable loss and an input amplifier with 26.5 dB of gain and with a noise figure of 4 dB. This level was arbitrarily chosen for this testing to allow some consistent reference for both commercial and military GPS units.

5.2 CW RF signal

The CW signal used for some testing is generated by an Agilent RF Signal Generator. The CW levels referred to during test are the output levels of the signal generator. The generator control is integrated into our LabView HPIB controller program.

The LabView program can control the levels of both the UWB and the CW signals.

6.0 DATA COLLECTION

The PCSG command file starts the recording of data onto the computer hard drive. MAGR output data blocks 3 and 1331 must be enabled by the command file and be recorded. The data will be recorded into the file name defined in the PCSG command file. To preserve previously collected data, it is important to erase or rename the recorded file before restarting a scenario.

The MAGR data collected will be logged and recorded with GPS time tags. This GPS time is the time the scenario is presenting to the GPS. This GPS time is not actual time nor run time. The GPS time will repeat every time a scenario is restarted.

Two files are created for each PCSG scenario run. A *.log file records the PCSG commands as they are executed. A *.pdf will record the MAGR output data. The file names are defined in the Command file that starts the scenario execution.

7.0 INDIVIDUAL TEST PROCEDURES

The test sequences will be defined in the following sections. Initially for all tests, interference noise will be off and CW interferer will be less than -190 dBW.

7.1 C/A-code and P-code Pseudorange Noise Tests

7.1.1 Initialization

1. Set the PCSG command file to output individual satellite power levels so that -151 dBW is presented at the MAGR input. The commands will also select whether P or C/A code is available from the satellites.
2. Start PCSG scenario with command file. The command file will connect the MAGR data blocks 3 and 1331. It will start logging data.
3. Initialize MAGR by manually loading position, time and date. Leave MAGR in INIT mode for at least one minute after scenario begins. This will allow download of the almanac information.
4. Set MAGR to NAV mode. Allow the MAGR to obtain a good position fix. This is when the MAGR Figure of Merit (FOM) is near 1. The FOM values range from 1 (very good fix) to 9 (no valid position fix).
5. For a C/A-code data collection, add noise at a level of +19 Pd dB (3 dB greater than the ARINC +16 Pd dB equivalent sky noise). For a P-code data set, add noise at a level of +22 Pd dB (6 dB greater than equivalent sky noise).

7.1.2 Collection of UWB interference data

1. Collect a five minute interval using -151 dBW GPS signal and added noise as defined above for C/A-code or P-code tracking. Record GPS time at start and end of timed run for use later in data post-processing.
2. Set up the LabView program to change the UWB attenuator settings every 5 minutes. Before the start of data collection, the approximate UWB levels should be determined. We must change the added noise level manually every 15 minutes. The added noise will be reduced 2 dB, 4 dB and then turned off for the three different back-off levels. The 2 dB back-off level should have at least 3 dB step changes in UWB interference power. For the 4 dB back-off level and the no added noise back-off level, the UWB attenuator step changes should be at least 2 dB. In the LabView program the UWB step sizes and number can be changed as desired, as well as the dwell time at each step. For data processing, step dwell times of greater then 10 minutes are desirable but 5 minutes will be used as the

nominal value.

3. Manually reduce the added noise level to the 2 dB back-off level. Start the LabView program and record start time. Record start time in GPS scenario time. At start time plus 15 minutes, manually reduce added noise to 4 dB back-off level. At start time plus 30 minutes, turn off DC power to noise source and noise amplifier. At start time plus 45 minutes, data collection sequence in completed. Record GPS time at the start and the end for use in data processing. Record the attenuation settings.
4. To verify that the performance has not changed during the run, set added noise to the level in 7.1.1 Step 5 and remove all UWB signal by setting attenuators to maximum attenuation. Collect data for 5 minutes. Record start and stop times.
5. Terminate the PCSG scenario run.
6. Rename the .log and .pdf files. Record the new file names and the associated data collection run conditions, GPS times, attenuator settings, etc. Copy files onto transferable media for data processing.

7.2 Position and signal strength

7.2.1 Initialization

1. Set the PCSG command file to output individual satellite power levels so that -151 dBW is presented at the MAGR input.
2. Start PCSG scenario with command file. The command file will connect the MAGR data blocks 3 and 1331. It will start logging data.
3. Initialize MAGR by manually loading position, time and date. Leave MAGR in INIT mode for at least one minute after scenario begins. This will allow download of the almanac information.
4. Set MAGR to NAV mode. Allow the MAGR to obtain a good position fix. This is when the MAGR Figure of Merit (FOM) is near 1. The FOM values range from 1 (very good fix) to 9 (no valid position fix). Record position information: Lat, Long and Altitude.
5. With no added noise or interference signals, adjust satellite signal levels to produce C/No value of 40 dB-Hz (approximately -160 dBW). Record satellite power level.
6. Add broadband noise at a level to reduce C/No value to 30 dB-Hz. Record noise level.

7.2.2 Determine Standard RFI power

1. Add CW interferer signal at 1575.8 MHz (L1+0.4 MHz) at a signal level enough to change the C/No 2 dB or the position 12 meters. Record CW signal level.

7.2.3 Collection of UWB interference data

1. Collect a five minute interval of data at the signal and interferer levels described above in Section 7.2.1. Record GPS time at start and end of timed run for use later in data processing
2. Set up the Labview program to change the UWB attenuator settings every 5 minutes. Before the start of data collection, the approximate UWB levels should

be determined. The Labview program will be set to reduce the CW level every 15 minutes. The CW interferer level will be reduced 2 dB and 4 dB below the level determined in Section 7.2.2, and then turned off for the three back-off levels. The 2 dB back-off level should have at least three 3 dB step changes in UWB power. For the 4 dB back-off level and the CW off condition, the three UWB step changes should be at least 2 dB different. The UWB step sizes and number can be changed as desired, as well as the dwell time at each step.

3. With the satellite signal power and the noise power determined in Section 7.2.1, start running the LabView program. Record GPS time at the start and the end for use in data processing. Record the attenuation and CW signal level settings.
4. To verify that the performance has not changed during the run, set the levels determined in steps 7.2.1 Steps 5 and 6 and 7.2.2 for signal, noise and CW levels. Remove all UWB signal by setting attenuators to maximum attenuation.
5. Terminate the PCSG scenario run.
6. Rename the .log and .pdf files. Record the new file names and the associated data collection run conditions, GPS times, attenuator settings, etc. Copy files onto transferable media for data processing

7.3 Direct P Code Reacquisition

For the MAGR to perform a direct P-L1 reacquisition, the receiver must be in a Jammed condition. The receiver must initially be tracking L1 in State 5 on all channels. L2 signals must not be available. The MAGR must continue to track in State 5 on at least 2 primary channels when the jammed satellite signals are blocked. The minimum J/S on the unjammed primary channels must be greater than 36 dB. Note that if all satellite signals are lost, the receiver does not consider itself jammed and will attempt reacquisition strategies other than a direct P code reacquisition.

7.3.1 Initialization

1. Create simulator command files that will perform the tasks in the following list. Samples of the command files (named in parenthesis) are included at the end of this document.
   - Turn Power off (pwroff.cmd). Set 3 of the 6 available satellite L1 and L2 powers to -190 dBW and the balance of the satellites to -158 dBW on L1 & L2 for 10 seconds
   - Set levels for reacquisition (prwacq.cmd). Turns all the SV powers to -158 dBW for L1 and turns all of the SV L2 power levels to -190 dBW for 40 seconds
   - Returns full power to all SVs (pwr150.cmd). Turns all satellites to -150 dBW for both L1 and L2 for 10 seconds
   - Repeat the power off, power reacquisition, full power sequence 10 times for 10 reacquisition attempts in 10 minutes (acq10.cmd). This was done with nested command files.
2. Set the PCSG command file to output individual satellite power levels so that -151 dBW is presented at the MAGR input
3. Start PCSG scenario with command file. The command file will connect the MAGR data blocks 3 and 1331. It will start logging data.

4. Initialize the MAGR by manually loading position, time and date. Leave the MAGR in INIT mode for at least one minute after scenario begins. This will allow download of the almanac information.
5. Set the MAGR to NAV mode. Allow the MAGR to obtain a good position fix. This is when the Figure of Merit (FOM) is near 1. The FOM values range from 1 (very good fix) to 9 (no valid position fix).

7.3.2 Determine Standard RFI power

1. To determine the baseline signal level, with no added noise interference signal, adjust satellite signal levels to produce a C/No value of 40 dB-Hz (approximately -160 dBW). Record satellite power level.
2. Add broadband noise at a level to reduce C/No values to 33, 31, 29 and 27 dB-Hz. Record noise attenuation settings to produce each of the four C/No levels.
3. Collect data to determine a baseline reacquisition time. Set the GPS signal level to that determined in step 1. The broadband noise interferer attenuation values will be the four settings determined in step 2.
4. Set the noise attenuator to one of the noise attenuator settings. Run the command file, referred to in 7.3.1 Step 1, which steps through 10 of the reacquisition sequences and collects data for 10 minutes. Record GPS time at start and end of the 10 minutes and the attenuator setting for use later in the data processing.
5. Repeat the 10 minute data collection for the other three attenuator settings, record the GPS start times and the attenuator setting.
6. The direct P code acquisition time is the number of seconds from the restoration of power to all the satellite signals to the time the Nav Invalid flag goes False. The reference baseline interference noise level is that attenuator setting which produces an average reacquisition time closest to 15 seconds. With no interferer, the average reacquisition time is about 5 seconds.

7.3.3 Collection of UWB interference data

1. Set up the LabView program to change the UWB attenuator setting every 10 minutes during the data collection run. Prior to the start of the automated data collection, the approximate UWB levels should be determined by visual observation of reacquisition time. The noise RFI power level will be backed off 2 dB and 4 dB from the level determined in 7.3.2 Step 6, and then turned off. For each standard interferer back-off level, some amount of UWB interferer power is added until the reacquisition time is reduced to a nominal 15 seconds. Once this approximate equivalent UWB power level is determined, the automated UWB power control attenuators are set to collect UWB power data at that level and 2 or 3 dB above and below it.
2. The 2 dB standard RFI reduction data should have at least 3 dB step changes in UWB power. For the 4 dB CW power reduction and the no added noise case, the UWB step changes should be at least 2 dB. The LabView program is set to change the UWB attenuator settings every 10 minutes. Our data collections record 3 UWB level settings for each noise RFI back off level. The added noise level must be manually changed every 30 minutes the 2 dB, 4 dB and no added noise levels from Step 1. The UWB step sizes and number can be changed as desired. The acq10 command file must be manually restarted every 10 minutes.

The manual change in noise level and the restart of the acq10 command must coincide with the UWB power changes made by the LabView program.

3. Repeat the previous step to collect 10 reacquisition trials for each back-off level and UWB attenuator setting set.
4. To verify that the performance has not changed during the run, set the signal levels determined in 7.3.2 Step 1 and the ref RFI noise level from 7.3.2 Step 6. Remove all UWB signal by setting attenuators to maximum attenuation. Run acq10 command program and collect data for 10 minutes. Record start and stop times.
5. Terminate the PCSG scenario run.
6. Rename .log and .pdf file. Record new file names and the associated data collection run conditions, GPS times, attenuator settings, etc. Copy files onto transferable media for data processing

7.4 Time to first fix (Optional test)

This test is not especially difficult, but it is cumbersome and very time consuming. Each GPS first fix time can take up to 5 minutes. Each re-initialization of the MAGR, to start a first fix search, must be done by hand and the re-initialization times hand logged.

1) Set the PCSG command file to output individual satellite power levels so that -151 dBW is presented at the MAGR input.
2) Start PCSG scenario with command file. The command file will connect the MAGR data blocks 3 and 1331. It will start logging data.
3) Initialize MAGR by manually loading position, time and date. Leave MAGR in INIT mode for at least one minute after scenario begins. This will allow download of the almanac information.
4) Set MAGR to NAV mode. Allow the MAGR to obtain a good position fix. This is when the MAGR Figure of Merit (FOM) is near 1. The FOM values range from 1 (very good fix) to 9 (no valid position fix). Record position information: Lat, Long and Altitude.
5) With no added noise or interference signals, adjust satellite signal levels to produce C/No value of 40 dB-Hz (approximately -160 dBW). Record satellite power level.
6) Add the broadband interferer noise at a level to reduce the C/No value to 28 dB-Hz. Record noise level.
7) Collect a stable run at the signal and interferer level values determined in steps 5 and 6. Restart the GPS scenario. Manually log the GPS time when satellite power is available and the GPS time when the Nav Invalid flag becomes false. Repeat the scenario restart for a total of 10 times. The average time to achieve a valid Nav condition is the baseline TTFF.
8) To obtain TTFF UWB data:
   a) Before the start of data collection, the approximate UWB levels should be determined. The broadband noise interferer level determined in Step 6 will be reduced 2 dB and 4 dB and then turned off.
   b) The 2 dB interference noise back off change should have at least three 3 dB step

changes in UWB power.

c) For the 4 dB interference noise back-off reduction and the no added noise condition, the three UWB step changes should be at least 2 dB apart. The UWB step sizes and number can be changed as desired, as well as the dwell time at each step.

d) With the satellite signal power from step 5 and the back-off noise level, start the scenario. Record the UWB attenuation and interferer signal level settings. The time the satellites become available will be constant for the scenario. Record the GPS time when the Nav Invalid flag becomes false. Repeat to obtain 10 TTFF times for each test condition of UWB and Noise interferer.

9) To verify that the performance has not changed during the run, repeat Step 7. Remove all UWB signal by setting attenuators to maximum attenuation.
10) Terminate the PCSG scenario run.
11) Rename .log and .pdf file. Record new file names and the associated data collection run conditions, GPS times, attenuator settings, etc. Copy files onto transferable media for data processing

8.0 POST-PROCESSING PROCEDURE

The following steps describe how to post-process the raw message block data collected during the tests in order to compute the performance metric levels for each of the back-off levels and each of the UWB attenuator settings. The appropriate raw message data must first be extracted using one (or two) DOS utilities and then subsequently processed in Matlab (or equivalent) in order to compute the performance values of interest. Once the performance metric data are computed and recorded with the associated levels of UWB interference used during the test, standard RFI equivalence factors can be computed.

8.1 Data Extraction and Performance Metric Computation

1. Decode .pdf file with pc_aptp.exe DOS utility if necessary.

   Ex. Assume the recorded data file is named 'run1.pdf'.

   >>pc_aptp -irun1.pdf

   The output file for subsequent data extraction is called 'run1.inp'.

2. Extract the relevant raw data with pc_prd.exe DOS utility.

   Ex. To extract the satellite PRN and C/N_0 data for all five channels of the MAGR from Block 3 the following command is used assuming the input file is 'run1.inp'.

   >>pc_prd -irun1.inp -occ.out /3/44,45,53,54,62,63,71,72,80,81/

   This command generates the output file 'cc.out'. This output file would have 11 columns, the first of which is the GPS time and the remaining 10 columns consist of the PRN and C/N_0 data for the five receiver channels.

3. Process data with Matlab or equivalent as described below for each type of test.

For PR noise tests:

1. Extract PR, DR and C/N_0 data from message Blocks 3 and 1331 for the MAGR channels
2. Read in to Matlab (Delete column headings from output file first.)
3. For each PRN do the following
   i. Filter out the correct PR and DR data
   ii. Filter out the correct C/N0 data
   iii. Retain only valid PR (PR Validity bit = 1) and DR (DR Validity flag = 2) data
   iv. Integrate DR data to compute Integrated DR. (Generates a pseudo carrier phase measurement in order to compute single difference residual.)
   v. Compute difference between PR and Integrated DR residual
   vi. Detrend residual (Since the MAGR does not output a true continuous carrier phase measurement, the Integrated DR serves as the closest proxy to carrier phase. However, the Integrated DR has a slight, but constant, drift relative to the PR measurement. The detrending operation has an insignificant effect on the PR noise variance.)
   vii. Select the intervals based on recorded GPS time where detrended is valid and PR 1-sigma noise should be computed. Plot data and inspect to insure that no discontinuities or obvious glitches are apparent over the interval.
   viii. Compute 1-sigma values of PR noise for the selected intervals and record computed values with the associated UWB attenuator setting.
   ix. Compute and record the average C/N_0 for the same interval

For the Position/Signal Strength test:

1. Extract the position and C/N_0 data from message Block 3
2. Read in to Matlab (Delete column headings of output file first.)
3. Retain only the valid data (Nav Invalid = N and FOM = 1)
4. Over all the UWB attenuation setting intervals
   i. Compute the horizontal and vertical position errors over the interval
   ii. Compute the average C/N_0 over the interval
   iii. Record computed values with the associated UWB attenuator setting.

For the Reacquisition test:

1. Extract the Nav Invalid flag data from message Block 3
2. Read in to Matlab (Delete column headings first.)
3. Over all the UWB attenuation setting intervals
   i. Determine the time to reacquisition (Nav Invalid = N from time signal power is restored) for each trial in the interval
   ii. Compute the average time to reacquisition values and record with the associated UWB attenuator setting.

For the TTFF test:

1. Extract the Nav Invalid flag data from message Block 3
2. Read in to Matlab (Delete column headings first.)

3. Over all the UWB attenuation setting intervals
   i. Determine the TTFF (Nav Invalid = N from time receiver is commanded to Navigation mode) for each trial in the interval
   ii. Compute the average TTFF values and record with the associated UWB attenuator setting.

8.2 Standard RFI Equivalence Factor Computation

Given the computation of the performance metric values from the recorded raw data as described in the previous section, it is necessary to determine the UWB power levels at which the metric's accuracy limit is achieved for each of the back-off levels. The test procedures designed such that accuracy limit will likely fall in the range of the values that are computed from the recorded data. However, this will not always occur. For example, the PR noise is directly observable during the data collection of the PR noise tests, so UWB attenuator settings must be estimated from C/N_0 readings. When the accuracy limit does not fall into the range of the post-processed performance metric values, then the UWB setting can be determined by extrapolating the computed metric values. In extreme cases where extrapolation of the computed metric values would be highly inaccurate, then additional data would need to be collected to estimate the UWB power level at which the accuracy limit is achieved.

Given the UWB attenuator settings, and hence, the UWB power values, at which the accuracy limit is achieved for each back-off level, it is then possible to compute the standard RFI equivalency factor for each waveform evaluated for each of the five tests. This computation is illustrated in Figure 2. The log of the slope is the waveform specific RFI equivalency factor (in dB) that can be used in RFI link budget analysis. Note that since three back-off levels are determined for each test and each waveform, it is possible to compute three different equivalency factors for each waveform in each test. Computing multiple equivalency factors can indicate whether the impact of UWB interference is linear or non-linear as a function of power.

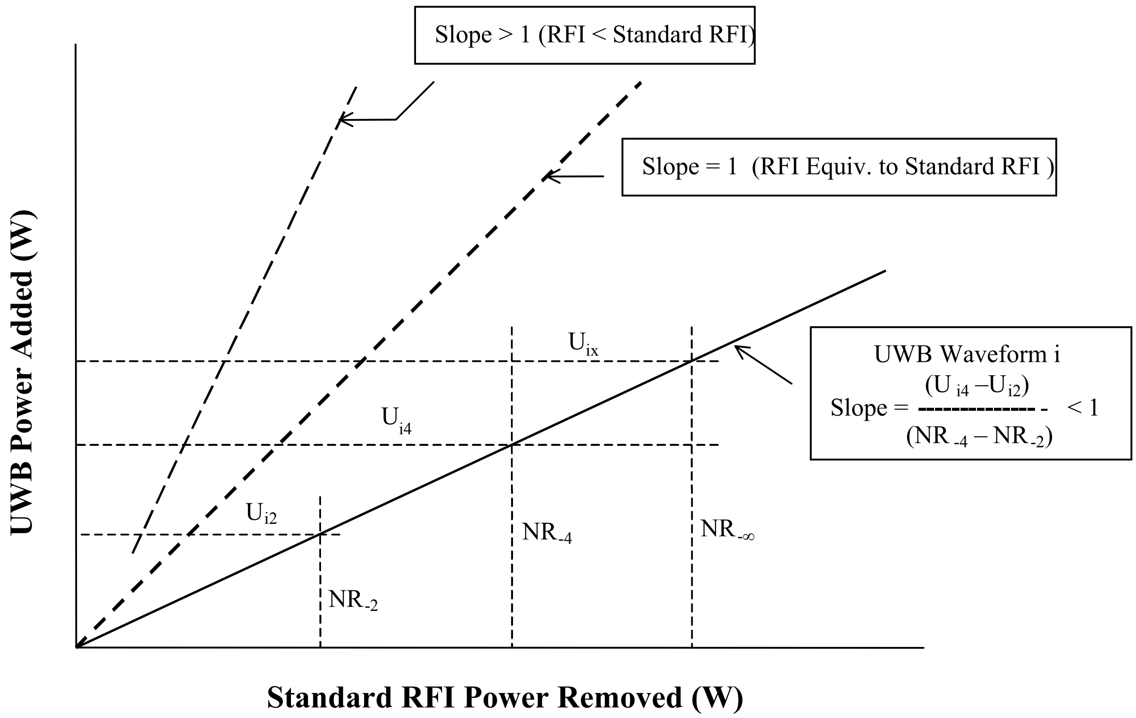

Figure 2. Standard RFI Equivalency Factor Graphical Description

Sample Data Sheet

Filename/Test ID________________________
Date__________________
Technician _____________

MAGR S/N ______
CDU S/N ________
Document and attach complete test equipment list

Calibration adjustments
Simulator output to MAGR input path loss =________dB
CW signal output to MAGR input path loss =_________dB
UWB output to MAGR input path loss =_________ dB
Noise power at MAGR input is +16 dB Pd with noise path attenuator set to ____dB

Satellite simulator scenario
Name___ ______________
Initial scenario position LAT_______ LONG________
Initial scenario time YEAR_________ DAY________ TIME_______

UWB modulation waveform ____________________________________
AWG waveform filename _____________________________________.wfm
AWG adjustments (if any):
AMPL _________V, OFFSET ___________V
CLOCK__________MHz

Start simulation scenario. Initialize MAGR with above time, date and position. After one minute to allow for almanac download, switch MAGR to NAV mode. Allow time for MAGR to achieve FOM of 1.

Simulator satellite power is –151 dBW for both CA and P code data collection.
______P code data requires noise power of +22 dB Pd.
______CA code data requires noise power of +19 dB Pd.

Determine correct normal operating conditions and set levels:
Record satellite signal level _____________dBW
Record noise path attenuator setting _____________________dB

Baseline data for CA______ or P______ code(select code)
Noise level attenuator settings ____dB
for 5 or ______ minutes
Data collection start time ____________
Data stop time______________

UWB step data:

Labview program start time_________________

Each program step is 5 or _____ minutes
UWB attenuation is added to UWB path loss

Control program step number	UWB attenuation	CW level @ signal generator (dBm)	First attenuator setting	Second attenuator setting
1				
2				
3				
4				
5				
6				
7				
8				
9				

Labview program end time ________________-

UWB off, 5 minutes minimum

Data start time_____________
Settings:
Simulator _______________dBW
Noise attenuator ___________dB
Data end time______________

Samples of PCSG Simulator Command Files Used in Test Procedure

ACQ10.CMD

```
@pwroff
@pwracq  /G:+10
@pwr150  /g:+40
@pwroff  /G:+10
@pwracq  /G:+10
@pwr150  /g:+40
@pwroff  /G:+10
@pwracq  /G:+10
@pwr150  /g:+40
@pwroff  /G:+10
@pwracq  /G:+10
@pwr150  /g:+40
@pwroff  /G:+10
@pwracq  /G:+10
@pwr150  /g:+40
@pwroff  /G:+10
@pwracq  /G:+10
@pwr150  /g:+40
@pwroff  /G:+10
@pwracq  /G:+10
@pwr150  /g:+40
@pwroff  /G:+10
@pwracq  /G:+10
@pwr150  /g:+40
@pwroff  /G:+10
@pwracq  /G:+10
@pwr150  /g:+40
@pwroff  /G:+10
@pwracq  /G:+10
@pwr150  /g:+40
```

CAFLAGS.CMD

```
sg cgen,code,1,p,both,off
sg cgen,code,2,p,both,off
sg cgen,code,3,p,both,off
sg cgen,code,4,p,both,off
sg cgen,code,5,p,both,off
sg cgen,code,6,p,both,off
sg cgen,code,7,p,both,off
sg cgen,code,8,p,both,off
sg cgen,code,9,p,both,off
sg cgen,code,10,p,both,off
sg cgen,code,11,p,both,off
sg cgen,code,12,p,both,off
sg cgen,code,13,p,both,off
sg cgen,code,14,p,both,off
sg cgen,code,15,p,both,off
sg cgen,code,16,p,both,off
sg cgen,code,17,p,both,off
```

```
sg cgen,code,18,p,both,off
sg cgen,code,19,p,both,off
sg cgen,code,20,p,both,off
sg cgen,code,21,p,both,off
sg cgen,code,22,p,both,off
sg cgen,code,23,p,both,off
sg cgen,code,24,p,both,off
sg cgen,code,25,p,both,off
sg cgen,code,26,p,both,off
sg cgen,code,27,p,both,off
sg cgen,code,28,p,both,off
sg cgen,code,29,p,both,off
sg cgen,code,30,p,both,off
sg cgen,code,31,p,both,off
sg cgen,code,32,p,both,off
sg dlnk,l2pdataflag,1,off
sg dlnk,l2pdataflag,2,off
sg dlnk,l2pdataflag,3,off
sg dlnk,l2pdataflag,4,off
sg dlnk,l2pdataflag,5,off
sg dlnk,l2pdataflag,6,off
sg dlnk,l2pdataflag,7,off
sg dlnk,l2pdataflag,8,off
sg dlnk,l2pdataflag,9,off
sg dlnk,l2pdataflag,10,ofF
sg dlnk,l2pdataflag,11,oFf
sg dlnk,l2pdataflag,12,off
sg dlnk,l2pdataflag,13,off
sg dlnk,l2pdataflag,14,off
sg dlnk,l2pdataflag,15,off
sg dlnk,l2pdataflag,16,off
sg dlnk,l2pdataflag,17,off
sg dlnk,l2pdataflag,18,off
sg dlnk,l2pdataflag,19,off
sg dlnk,l2pdataflag,20,off
sg dlnk,l2pdataflag,21,off
sg dlnk,l2pdataflag,22,off
sg dlnk,l2pdataflag,23,off
sg dlnk,l2pdataflag,24,off
sg dlnk,l2pdataflag,25,off
sg dlnk,l2pdataflag,26,off
sg dlnk,l2pdataflag,27,off
sg dlnk,l2pdataflag,28,off
sg dlnk,l2pdataflag,29,off
sg dlnk,l2pdataflag,30,off
sg dlnk,l2pdataflag,31,off
sg dlnk,l2pdataflag,32,off
sg dlnk,datamod,1,p,both,off
sg dlnk,datamod,2,p,both,off
sg dlnk,datamod,3,p,both,off
sg dlnk,datamod,4,p,both,off
sg dlnk,datamod,5,p,both,off
sg dlnk,datamod,6,p,both,off
sg dlnk,datamod,7,p,both,off
sg dlnk,datamod,8,p,both,off
sg dlnk,datamod,9,p,both,off
```

sg dlnk,datamod,10,p,both,off
sg dlnk,datamod,11,p,both,off
sg dlnk,datamod,12,p,both,off
sg dlnk,datamod,13,p,both,off
sg dlnk,datamod,14,p,both,off
sg dlnk,datamod,15,p,both,off
sg dlnk,datamod,16,p,both,off
sg dlnk,datamod,17,p,both,off
sg dlnk,datamod,18,p,both,off
sg dlnk,datamod,19,p,both,off
sg dlnk,datamod,20,p,both,off
sg dlnk,datamod,21,p,both,off
sg dlnk,datamod,22,p,both,off
sg dlnk,datamod,23,p,both,off
sg dlnk,datamod,24,p,both,off
sg dlnk,datamod,25,p,both,off
sg dlnk,datamod,26,p,both,off
sg dlnk,datamod,27,p,both,off
sg dlnk,datamod,28,p,both,off
sg dlnk,datamod,29,p,both,off
sg dlnk,datamod,30,p,both,off
sg dlnk,datamod,31,p,both,off
sg dlnk,datamod,32,p,both,off

PGDOFF.CMD
SG CHAN,1,CGEN,P,BOTH,OFF
SG CHAN,2,CGEN,P,BOTH,OFF
SG CHAN,3,CGEN,P,BOTH,OFF
SG CHAN,4,CGEN,P,BOTH,OFF
SG CHAN,5,CGEN,P,BOTH,OFF
SG CHAN,6,CGEN,P,BOTH,OFF

PWR150.CMD
MC SIGNAL, ATTEN, -1,0,BOTH
MC signal,nominal,1,-150,both
Mc signal,nominal,2,-150,both
mc signal,nominal,3,-150,both
mc signal,nominal,4,-150,both
Mc signal,nominal,5,-150,both
mc signal,nominal,6,-150,both

PWRACQ.CMD
MC SIGNAL, ATTEN, -1,0,BOTH
MC signal,nominal,1,-158,l1
Mc signal,nominal,2,-158,l1
mc signal,nominal,3,-158,l1
mc signal,nominal,4,-158,l1
Mc signal,nominal,5,-158,l1
mc signal,nominal,6,-158,l1
mc signal,nominal,1,-190,l2

```
mc signal,nominal,2,-190,l2
mc signal,nominal,3,-190,l2
mc signal,nominal,4,-190,l2
mc signal,nominal,5,-190,l2
mc signal,nominal,6,-190,l2
```

PWROFF.cmd

```
ss altfmt,sgpower2
mc signal,nominal,2,-190,both
Mc signal,nominal,3,-190,both
mc signal,nominal,4,-190,both
mc signal,nominal,6,-190,both
mc signal,nominal,1,-158,both
mc signal,nominal,5,-158,both
```

TTFFRUN.CMD

```
RFSRC   = PCSG
IPSRC   = FTIC
SMODE   = NORMAL
IDFMODE  = NORMAL
IDF    = c:\mam\static\mg1005y.idf
DNL    = C:\SEVS\FTIC_DNL\magr3a.PC
ACTI    = DISC,HVI IP,TM,1553
CATS    = 30,31,43
CMD    = MINSTA1
CMD    = MENG6ANS
CMD    = MANDR
cmd    = meni1
CMD    = MENI24
CMD    = MENI5B
CMD    = MENI5C
CMD    = MENFC
CMD    = SIM BB REQUEST, BLOCK, 1331, ON
CMD    = .DELAY 5S
CMD    = BB RECO
ENABLE  = FTIC
ENABLE  = FC2
ENABLE  = PCSG
DISABLE  = DEV4
DISABLE  = DEV5
DISABLE  = DEV6
DISABLE  = DEV7
DISABLE  = DEV8
DISABLE  = DEV9
LOG    = ttffdata.LOG
PDF    = ttffdata.PDF
EXECUTE  = YES
START   = YES  /S:+20.
cmd    = @pwr150 /g:61035
cmd        = sim ft hvi,1553,enable,i2
cmd        = ss enable,30,31,32,33
```

```
cmd     = sim ft hvi,1553,rh,i1,1,a000  /g:62000
cmd     = sim ft hvi,1553,itime,1983,12,25,16,50  /g:62010
cmd     = sim ft hvi,1553,rh,i2,1,ff00  /g:62015
cmd     = sim ft hvi,1553,igdpos,long,-114,22,50  /g:62020
cmd     = sim ft hvi,1553,igdpos,lat,33,00,00  /g:62022
cmd     = sim ft hvi,1553,rh,i2,1,0000  /g:62025
cmd     = sim ft hvi,1553,disable,i6  /g:62027
cmd     = sim ft hvi,1553,disable,i11  /g:62028
cmd     = sim ft hvi,1553,rh,i1,1,c000  /g:62029
cmd     = sim ssstop,nowait  /g:62629
```

TTFF.BAT

```
sscds @TTFFrun
sscds @TTFFrun
sscds @TTFFrun
sscds @TTFFrun
sscds @TTFFrun
sscds @TTFFrun
sscds @TTFFrun
sscds @TTFFrun
sscds @TTFFrun
sscds @TTFFrun
:exit
```

APPENDIX G
UWB EMI TEST PLAN FOR THE AN/APX-100 IFF SYSTEM

1.0 INTRODUCTION

The AN/APX-100 identification friend or foe (IFF) system provides automatic identification for aircraft. The system consists of an interrogator that transmits a coded pulse signal and a transponder that receives the interrogation, decodes the interrogation pulses and if the code is correct, automatically transmits a coded reply.

The IFF system is considered a secondary radar system since it operates with a transponder and is independent of the primary radar system that tracks aircraft skin returns only. The advantage of the transponder is that the coded pulses ‘‘squawked’’ by the aircraft transponders after being interrogated might typically be transmitted at a 500 watt effective isotropic radiated power (EIRP) which is much stronger than the microwatt skin return to the primary radar. The transponder antenna is low gain so that it can receive and reply to a radar from any direction.

A cross-band beacon is used, which means that the interrogation pulses are at one frequency and the reply pulses are at a different frequency. A frequency of 1030 MHz is used for the interrogation and 1090 MHz is used for the reply. The AN/APX-100 has an IF bandwidth of 9.8 MHz and a nominal sensitivity of –77 dBm

There are five modes of operation currently in use:

- Mode 1 is a military code set by the pilot
- Mode 2 is a military ID usually squadron
- Mode 3A is used by the FAA for identification of civilian aircraft by flight number
- Mode 3C is the civilian mode used for reporting altitude
- Mode 4 is secure encrypted IFF (which is used for determining friend or foe)

Modes 1, 2, and 3A are termed Selective Identification Features (SIF) and the codes are manually set by the pilot. The code for Mode 3C is obtained from the radar altimeter. Air traffic control primary radars are two-dimensional search radars (working in azimuth and range only) and cannot measure altitude. Mode 4 is used for classified encrypted purposes.

2.0 OVERALL TEST OBJECTIVE

The overall objective of the test is to determine the EMI susceptibility of the IFF to conducted ultra-wideband (UWB) signals that are injected into the receiver antenna port. The results of this investigation shall provide the information necessary to evaluate the potential for UWB signals to interfere with the IFF and to understand how UWB systems could be implemented to make use of their unique capabilities without causing electromagnetic interference (EMI).

3.0 TEST APPROACH

In order to accomplish the test objective, there are several parameters that must be measured. These parameters are the sensitivity of the receiver to the desired signal and the susceptibility of the receiver to typical UWB interfering signals. The test shall be performed with the IFF receiver operating in various modes.

The tests will be performed by personnel that are familiar with EMI test equipment and are knowledgeable about EMI test procedures and techniques. The test personnel that will be performing the tests work at the Naval Air Warfare Center Aircraft Division (NAWC AD) Electromagnetic Environmental Effects (E^3) facility where the tests will be performed. These personnel are experienced EMI testing specialists. For the type of scientific testing required for this project, detailed "cookbook" test procedures may be too restrictive and may impede testing. Therefore, detailed test procedures are not considered to be necessary and will not be provided in the test plan.

4.0 UWB WAVEFORMS

The UWB waveform parameters that shall be used for the AN/APX-100 receiver shall be selected from the set of waveforms that are presented below. When a filtered waveform is used, the 950 MHz to 1,250 MHz filter for the UWB signal shall be selected so the UWB operating band falls across the AN/APX-100 receive band, 1025.1 to 1034.9 MHz. When the waveform is generated by a baseband pulse, the selection of the frequency band does not apply.

The first five waveforms described below shall provide the most EMI impact that a UWB waveform shall have on an IFF receiver. If there is no EMI impact with any of the first five waveforms, there probably shall not be any impact with any of the other waveforms and the testing can end at this point. If any of the first five waveforms have an EMI impact, further testing is required to better characterize the impact. The tests shall be performed using the waveform parameters defined below.

4.1 Test Waveform One (TW1)

For the first test waveform, the pulse repetition frequency (PRF) of the UWB signal shall be the maximum value available from the pulse generator that results in the fundamental or one harmonic of the UWB PRF falling within the operating range of the AN/APX-100 receiver, 1025.1 to 1034.9 MHz. Since the maximum PRF available from the pulse generator is 100 MHz and no harmonic of 100 MHz equals 1030 MHz or falls within the receiver bandwidth, a lower frequency must be chosen. A PRF of 93.6 MHz shall be used. The 11th harmonic of 93.6 MHz is 1029.6 MHz which falls within the IF passband of the receiver. This first test waveform shall not be dithered nor modulated.

4.2 Test Waveform Two (TW2)

For the second test waveform, the basic PRF of the UWB signal shall be the same as that described for the first test waveform (i.e., 93.6 MHz) but the pulses shall be randomly dithered ± 5 %. At the receiver frequency, the interference shall be varying from 1024.92 to 1034.28 MHz, a slightly larger bandwidth than that of the receiver. This shall result in a noise-like signal filling the receiver intermediate frequency (IF) passband.

4.3 Test Waveform Three (TW3)

For the third test waveform, the PRF of the UWB signal shall be equal to the receiver IF bandwidth, 9.8 MHz, and the signal shall be dithered ± 25 %. At the receiver frequency, the interference shall be vary from 1027.55 to 1032.45 MHz, which is half the bandwidth of the receiver. This will result in a noise-like signal in the IF passband.

4.4 Test Waveform Four (TW4)

For the fourth test waveform, the PRF of the UWB signal shall be equal to the IF bandwidth of the receiver, 9.8 MHz, and the pulses shall not be dithered but the waveform shall be pulse position modulation (PPM) in a fashion similar to the actual IFF interrogation for the mode being tested. The resulting interfering signal will a modulated signal in the IFF's IF passband similar to an actual IFF interrogation.

4.5 Test Waveform Five (TW5)

For the fifth test waveform, the PRF of the UWB signal shall be 0.1 times the receiver IF bandwidth. Therefore, the PRF of the UWB shall be 980 kHz, and individual pulses will appear in the IF passband

4.6 Test Waveforms Six (TW6) and Seven (TW7)

Waveforms 6 and 7 in the Test Master Plan specify a PRF that is ten times (10X) the IF bandwidth of the receiver. For the IFF receiver, the IF bandwidth is 9.8 MHz; therefore, the PRF for waveforms 6 and 7 would be 98 MHz. Because the IFF receiver is fixed tuned and the UWB modulator cannot exceed 100 MHz, the UWB waveform would have to be tuned to the next lower frequency which has a harmonic in the IFF passband. This would result in a PRF of 93.6 MHz, which is the same PRF used for TW1 and TW2. Therefore, TW6 and TW7 do not add any additional information on the susceptibility of the IFF receiver to UWB emitters.

5.0 RECEIVER SUSCEPTIBILITY TEST

The objective of the receiver susceptibility tests is to obtain data that will provide useful information on the susceptibility of IFF receivers to UWB interference. The tests will be performed using either one or two signals. With the one signal tests, a UWB interfering signal is input to the receiver under test and the output is observed. The receiver is considered to be susceptible if the UWB interfering signal produces a detectable change in the receiver output. No intended in-band signal is used for this test. For the IFF receiver, the concern is that EMI may cause false interrogations that will result in false replies.

The two signal susceptibility tests described in this test plan require that the receiver desired signal and a UWB interfering signal be simultaneously injected into the receiver antenna port. The concern is that EMI can cause the transponder to miss interrogations that will result in a decrease in the reply rate. The minimum acceptable reply rate is 90%. This is defined as the standard response and is used to determine the receiver sensitivity that provides the basis for these susceptibility tests. The sensitivity is measured before the susceptibility tests are performed.

There are two approaches that may be used for the two signal susceptibility tests. For the first approach, the desired signal level is fixed at a level that is 6 dB above the "standard response acquisition threshold" (ACQ). The receiver susceptibility to UWB interference is determined by slowly increasing the UWB signal strength until the receiver can no longer maintain a standard response. The UWB interference level that degrades the receiver below the standard response condition is referred to as the "interference upset level" (IUPSET). The UWB interfering signal is then increased to 20 dB above the Upset Level and slowly reduced until the standard response is reestablished. The level of the UWB interfering signal at which the standard response is reestablished is the "reacquisition level" (REACQ). These levels describe the effect of the UWB interfering signal when the desired signal is close to the standard response threshold.

For the second approach, a high level UWB interfering signal (e.g., 20 dB above the receiver sensitivity) is injected and the desired signal level that is required for satisfactory operation of the receiver is determined. The information obtained from this test may be used to determine the reduction in range that the receiver will experience as a result of UWB interference. These levels are a better indication of the degradation resulting from UWB interference when the receiver has significant desired signal to operate with and is more typical of normal operations.

5.1 RECEIVER Sensitivity Measurement

The receiver sensitivity level is specified as the signal level required to create an appropriate standard response that results in satisfactory operation of the receiver. The degradation criterion for IFF systems is based on the reply rate. Ideally, an IFF system shall provide a 100% reply rate. That is, the IFF should reply to each interrogation. However, for test purposes, a reply rate of at least 90% is considered to be acceptable. The receiver standard response level is the signal level necessary to produce a 90% reply rate. The nominal receiver sensitivity is –77 dBm at the receiver input, or -74 dBm at the antenna output. For purposes of these tests, -77 dBm at the receiver input will be the receiver sensitivity criterion.

5.1.1 Receiver Sensitivity Measurement Objective

The objective of this test is to determine the standard response level, (i.e., the input signal level that is required for the transponder to provide a reply rate of at least 90% when there is no interference present).

5.1.2 Receiver Sensitivity Measurement Test Setup

The test set-up for the receiver sensitivity measurement is shown in Figure 1. An IFF test set (AN/APM-XXX) is used to generate the interrogation signal. A spectrum analyzer is used to monitor and measure the signal levels at the input to the IFF receiver under test. A pre-amplifier connected at the input of the spectrum analyzer may be required to observe the signal during the sensitivity test. Alternatively, after the sensitivity level is established, the signal level can be raised by a known, fixed amount (e.g., 40 dB) to enable the spectrum analyzer measurement to be made.

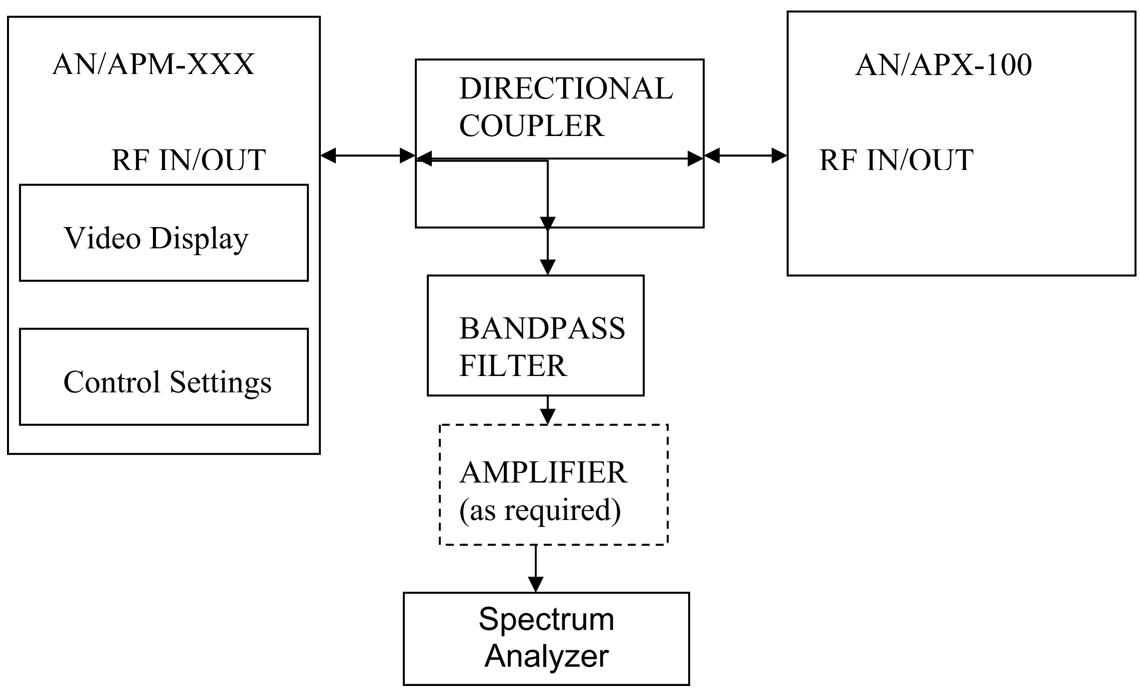

Figure 1. Receiver Sensitivity Test Set-Up

Spectrum analyzer levels shall be corrected for the pre-amplifier gain (if used) plus coupler and/or cable losses that exist in the measurement system. The AN/APX –111(V) receiver operation is verified to be satisfactory by monitoring the receiver output as displayed on the AN/APM-XXX to ensure that the interrogation reply rate is at least 90%.

5.1.3 Receiver Sensitivity Test Procedure

The AN/APX-100 shall be tested in each of the modes listed in Section 1.0 above. The general test procedure for determining receiver sensitivity for operation in a fixed frequency mode is as follows:

32. Connect the AN/APX-100 to the AN/APM-XXX in accordance with normal test procedures as modified in Figure 1. Set AN/APM-XXX to the desired mode and adjust for minimum power output. Verify that the receiver has not achieved a standard response condition for the low level signal.

33. Increase the AN/APM-XXX output power level until the AN/APM-XXX output monitor indicates a reply rate of 90%. Be sure to pause between each increase in signal power by an amount exceeding the maximum specified settling time for the receiver. Record the input power level at which the ACQ (i.e., 90% reply rate) was first observed on the data sheet in Table 1.

34. Increase the input power level an additional 10 dB above ACQ. This should result in a reply rate than 90%.

35. Decrease the input power until the reply rate drops below 90%. Record this level as the signal upset (SUPSET) threshold on the data sheet in Table 1.

36. Repeat steps 1 through 4 for each mode of operation.

TABLE 1

DATA SHEET FOR SENSITIVITY MEASUREMENTS

Receiver: AN/APX-100
Frequency Band: 1030 MHz
Receiver Modes: 1, 2, 3A, 3C, 4
Test Frequencies: 1030 MHz
Standard Response Criterion: 90% Reply Rate
Desired Signal Modulation: PPM
IF Bandwidth: 9.8 MHz
Sensitivity: -77 dBm

RCVR FRQ (MHz)	RCVR MODE	ACQ (dBm)	SUPSET (dBm)	NOTES (Record ACQ and SUPSET for each measurement here and average in column at left)
1030	1			
1030	2			
1030	3A			
1030	3C			
1030	4			

NOTE: Sensitivity threshold levels are inherently statistical and thus this procedure shall be conducted multiple times to obtain a representative sample of the threshold level.

NOTE: Because the receive and the transmit signals use the same antenna, but at different frequencies, it shall be necessary to isolate the test instrumentation from the effects of the transmit signal. This is best done through a combination of a single direction directional coupler and a very narrow band bandpass filter tuned to the IFF interrogation frequency, 1030 MHz. The 3 dB bandwidth of the filter shall be less than or equal to 1 MHz, but than or equal to 9.8 MHz in order to allow the full interrogation signal to pass. The filter's signal rejection at the IFF transponder frequency, 1090 MHz, shall be than or equal to 60 dB. If an amplifier is required, the gain shall be at least 10 dB than the attenuation of the directional coupler in order to get the minimum IFF interrogation signal above the spectrum analyzer noise floor, typically -80 dBm/MHz.

5.1.4 Receiver Sensitivity Measurement Output

The required results from the Receiver Sensitivity Test consist of documenting the ACQ and the SUPSET threshold on the appropriate line of the data sheet provided in Table 1. An average threshold value shall be specified if significant differences exist between the thresholds determined for each of the interrogation modes.

5.2 Receiver Susceptibility To White Noise

5.2.1 Receiver Susceptibility To White Noise Test Objective

The objective of this EMI test is to determine the susceptibility of an AN/APX-100 receiver (operating with a desired signal at the standard response level) to white noise interference. Susceptibility thresholds shall be determined by monitoring the output of the receiver and measuring the standard response level.

5.2.2 Receiver Susceptibility To White Noise Test Setup

The test setup is shown in Figure 2.

5.2.3 Receiver Susceptibility To White Noise Test Procedure

The general test procedure for determining receiver susceptibility to interference when the desired signal is at the standard response level and the receiver is operating at a fixed frequency is as follows:

29. Set the AN/APM-XXX to the ACQ level for the appropriate mode shown in Table 1.

30. Activate the white noise source at a level that is at least 10 dB below the SUPSET level for the appropriate mode shown in Table 1. If interference to the desired signal is observed, reduce the white noise level to 10 dB below the lowest level at

which interference is noted or maximum attenuation.

31. Slowly increase the white noise power level until there is an indication of impact on the receiver standard response condition (i.e., a decrease in the Reply Response %). Note that the spectrum analyzer resolution bandwidth will not be as wide as the RF bandwidth of the IFF receiver, 9.8 MHz. The average noise level shall be measured using the spectrum analyzer with a Resolution Bandwidth (RBW) of 1 MHz (or greatest available spectrum analyzer RBW equal to or less than the IFF IF passband). The spectrum analyzer Video Bandwidth (VBW) shall be equal to or than RBW. Empirical or calculated bandwidth correction factors shall be used to adjust the readings to the IF bandwidth of the receiver. Record this level as the “desired signal upset threshold” (WNUPSET) level in Table 2.

32. Increase the white noise level at least 10 dB above the WNUPSET level.

33. Slowly decrease the white noise level until the receiver re-achieves the standard response condition. Record this level as the reacquisition threshold (WNREACQ) level. This level may be the same as WNUPSET.

34. Repeat Steps 1 through 5 for each different receiver operating mode.

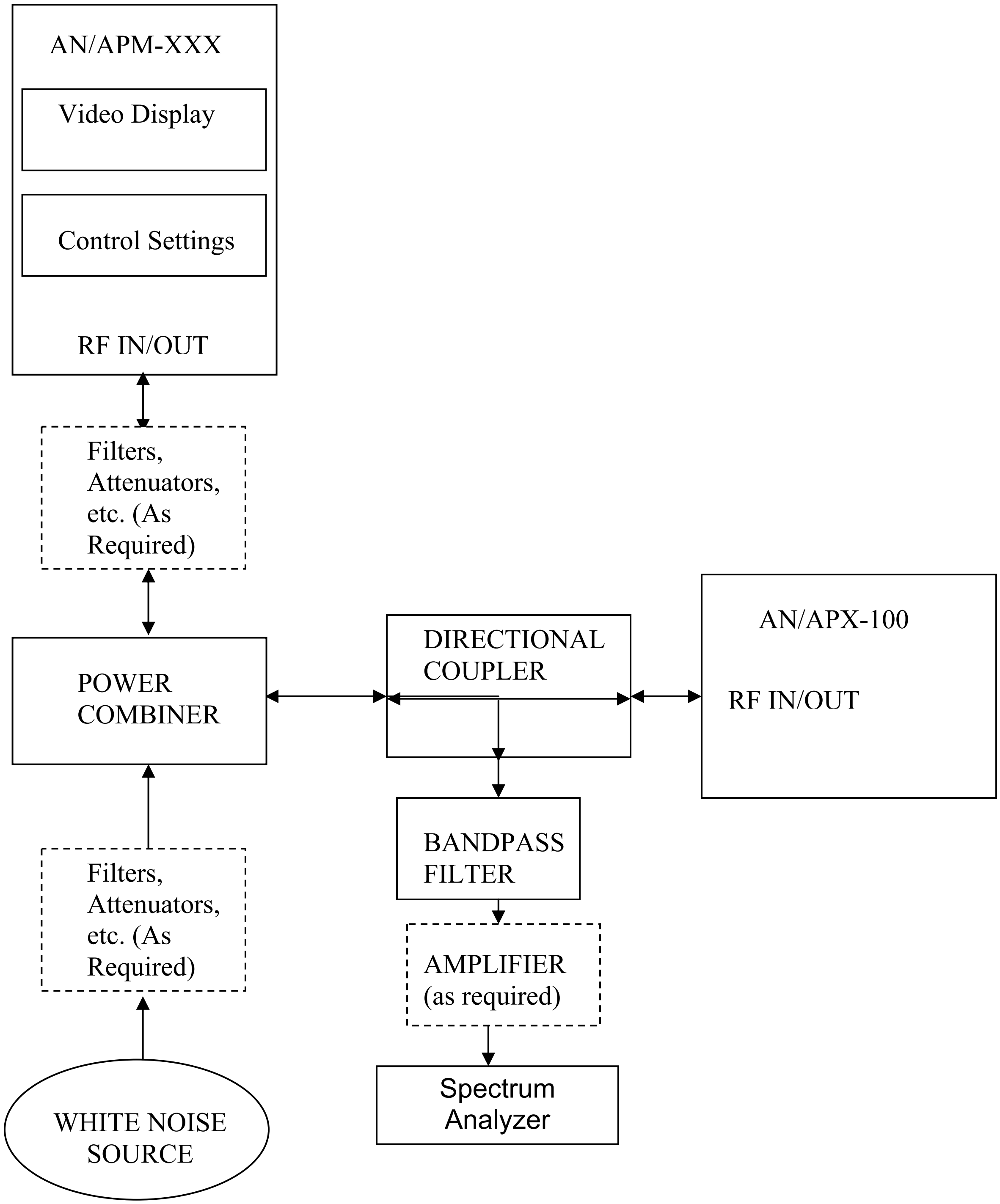

Figure 2. Conducted Susceptibility Test Set-Up-Two Signal Method

TABLE 2
DATA SHEET FOR WHITE NOISE TESTS

Receiver: AN/APX-100
Frequency Band: 1030 MHz
Receiver Mode: 1, 2, 3A, 3C, 4 (Circle applicable mode)
Test Frequencies: 1030 MHz
Standard Response Criterion: 90% Reply Rate
Desired Signal Modulation: PPM
Sensitivity: -77 dBm

	SIGNAL LEVEL (dBm)	NOISE LEVEL (dBm)
ACQ		N/A
WNUPSET		
WNREACQ		

5.2.4 Receiver Susceptibility To White Noise Test Output

The required results from the Receiver Susceptibility To White Noise Test consist of documenting the ACQ, the WNUPSET and the WNREACQ on the appropriate lines of the data sheet provided in Table 2 for the appropriate IFF mode.

5.3 One Signal Receiver Susceptibility – False Interrogations

5.3.1 One Signal Receiver Susceptibility – False Interrogations Test Objective

The objective of this test is to determine the impact of a UWB interfering signal to creating false interrogations in the receiver that shall result in false replies.

5.3.2 One Signal Receiver Susceptibility – False Interrogations Test Setup

The test setup is the same as the one shown in Figure 3. However, the test set is not interrogating on any of the IFF Modes.

5.3.3 One Signal Receiver Susceptibility – False Interrogations Test Procedures

1. Set the interrogator so it is not interrogating any of the IFF Modes. If necessary, turn the interrogator OFF.

2. Activate the UWB interference signal source with the first UWB test waveform at a maximum power level.

3. Monitor the output of the transponder and note if there are any false replies.

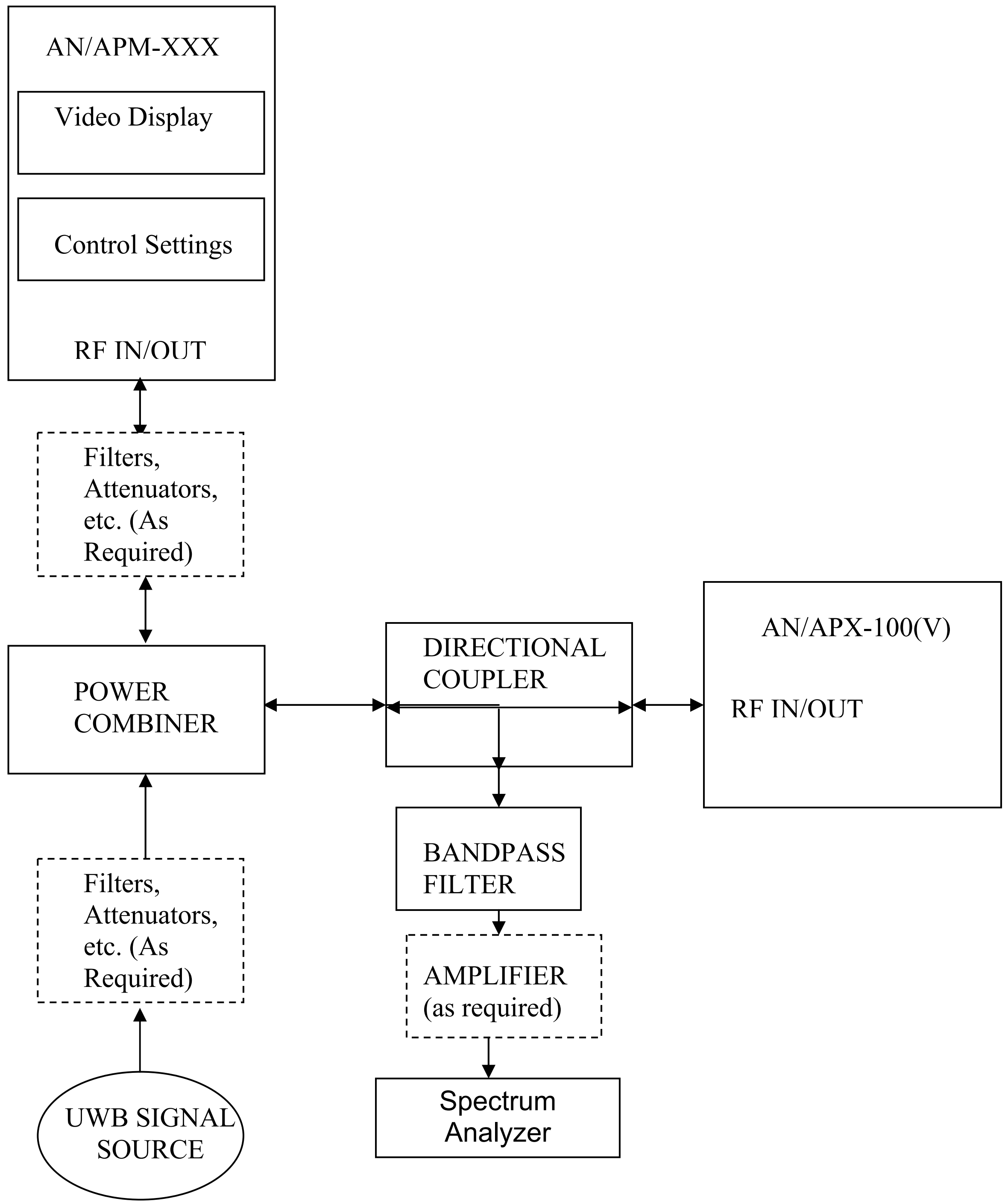

Figure 3. Conducted Susceptibility Test Set-Up-Two Signal Method

4. If there are any false replies, reduce the level of the UWB interfering signal until there are no false replies. Record this as the "False Reply Interference Threshold" (FRIT) in Table 3.

5. Repeat Steps 1 through 4 for the other UWB waveforms.

TABLE 3
DATA SHEET FOR ONE SIGNAL SUSCEPTIBILITY TEST

Receiver: AN/APX-100
Frequency Band: 1030 MHz
Receiver Mode: 1, 2, 3A, 3C, 4 (Circle applicable mode)
Test Frequencies: 1030 MHz
Standard Response Criterion: 90% Reply Rate
Desired Signal Modulation: PPM
IF Bandwidth: 9.8 MHz
Sensitivity: -77 dBm

RX FRQ (MHz)	UWB SIGNAL	PRF (MHz)	UWB MOD	FRIT (dBm)
1030	**1**	**93.6**	**NONE**	
1030	**2**	**93.6**	**DITHERED ± 5%**	
1030	**3**	**9.8**	**DITHERED ± 25%**	
1030	**4**	**9.8**	**PPM**	
1030	**5**	**0.980**	**NONE**	

NOTE: The spectrum analyzer resolution and video bandwidths will not be as wide as the RF bandwidth of the UWB waveform. The RBW of the spectrum analyzer shall be 1 MHz or the spectrum analyzer RBW closest to, but not exceeding, 9.8 MHz. The spectrum analyzer VBW shall be equal to or than the RBW. Empirical or calculated bandwidth correction factors shall be used to adjust the measurement of the UWB waveform to the IF bandwidth of the receiver. Average measurements shall be made for all of the test waveforms except for Waveform 5 which shall be made as a peak measurement. Record the interfering signal conditions (signal parameters and levels) that cause an impact on the receiver output.

5.3.4 One Signal Receiver Susceptibility – False Interrogations Test Output

The required results from the One Signal Receiver Susceptibility – False Interrogations Test consist of documenting the "False Reply Interference Threshold" (FRIT) on the appropriate lines of the data sheet provided in Table 3 for the appropriate IFF mode.

5.4 Receiver Susceptibility- Missed Interrogations - Standard Response Desired Signal

5.4.1 Receiver Susceptibility- Missed Interrogations - Standard Response Desired Signal Test Objective

The objective of this EMI test is to determine the susceptibility of an AN/APX-100(V) receiver (operating with a desired signal at the standard response level) to UWB interfering signals. Susceptibility thresholds shall be determined by monitoring the output of the receiver and measuring the standard response level.

5.4.2 Receiver Susceptibility- Missed Interrogations - Standard Response Desired Signal Test Setup

The test setup is shown in Figure 3.

5.4.3 Receiver Susceptibility- Missed Interrogations - Standard Response Desired Signal Test Procedure

The general test procedure for determining receiver susceptibility to interference when the desired signal is at the standard response level is as follows:

1. Set the interrogator to the selected test mode and adjust output power level to 6 dB above the ACQ level recorded in Table 1. Decreased the desired signal to the SUPSET recorded in Table 1. Record this level as the Desired Signal Level (DSL) in Table 4 for the specified UWB waveform. Verify that the receiver output exceeds the standard response condition (i.e. 90% Reply Rate).

2. Activate the UWB interference signal source with one of the UWB test waveforms at a level that is at least 20 dB below SUPSET.

NOTE: The spectrum analyzer resolution bandwidth will not be as wide as the RF bandwidth of the IFF receiver, 9.8 MHz. The average noise level shall be measured using the spectrum analyzer with a RBW of 1 MHz (or greatest available spectrum analyzer RBW equal to or less than the IFF IF passband). The spectrum analyzer VBW shall be equal to or than RBW. Empirical or calculated bandwidth correction factors shall be used to adjust the readings to the IF bandwidth of the receiver.

3. Increase the UWB interference signal power level until there is an indication of impact on the receiver standard response condition (i.e., a decrease in the reply rate). Record this level as the IUPSET level in Table 4. Record IUPSET – DSL as the interference-to-signal ratio (I/S).

4. Adjust the desired signal level to 6 dB above the ACQ level recorded in Table 1.

Record this level as the DSL on the second row for the selected UWB waveform.

5. Set the UWB interfering signal to the maximum level available. If the standard response condition is impacted, slowly decrease the UWB interference signal power until the receiver returns to a standard response. Record this interference level in Table 4 as the REACQ level. Record REACQ – DSL as the I/S ratio in Table 4.

6. Repeat Steps 1 through 5 for each UWB waveform.

7. Repeat Steps 1 through 6 for each IFF operating mode.

5.4.4 Receiver Susceptibility- Missed Interrogations - Standard Response Desired Signal Test Output

The required results from the two signal EMI tests consist of recording the desired signal level for the ACQ, the "desired signal upset threshold," and calculating the difference between these levels as the Interference-to-Signal Ratio (I/S). Also, the interfering signal level for the IUPSET, the ACQ and the calculated difference between these levels as the Interference-to-Signal Ratio (I/S). These shall be recorded on the appropriate lines of the applicable data sheet for the interference signal modulations and receiver mode of operation.

TABLE 4
RECEIVER SUSCEPTIBILITY- MISSED INTERROGATIONS - STANDARD RESPONSE DESIRED SIGNAL

Receiver: AN/APX-100
Frequency Band: 1030 MHz
Test Frequencies: 1030 MHz
Receiver Mode: 1, 2, 3A, 3C, 4 (Circle applicable mode)
Standard Response Criterion: 90% Reply Rate
Desired Signal Modulation: PPM
Sensitivity: - 77 dBm

RX FRQ (MHz)	UWB SIGNAL	PRF (MHz)	UWB MOD	DSL (dBm)	IUPSET (dBm)	REACQ (dBm)	I/S (dB)
1030	1	93.6	NONE			X	
1030	1	93.6	NONE		X		
1030	2	93.6	DITHERED ± 5%			X	
1030	2	93.6	DITHERED ± 5%		X		
1030	3	9.8	DITHERED ± 25%			X	

RX FRQ (MHz)	UWB SIGNAL	PRF (MHz)	UWB MOD	DSL (dBm)	IUPSET (dBm)	REACQ (dBm)	I/S (dB)
1030	**3**	**9.8**	**DITHERED ± 25%**		**X**		
1030	**4**	**9.8**	**PPM**			**X**	
1030	**4**	**9.8**	**PPM**		**X**		
1030	**5**	**0.980**	**NONE**			**X**	
1030	**5**	**0.980**	**NONE**		**X**		

NOTE: The spectrum analyzer resolution and video bandwidths will not be as wide as the RF bandwidth of the UWB waveform. The RBW of the spectrum analyzer shall be 1 MHz or the spectrum analyzer RBW closest to, but not exceeding, 9.8 MHz. The spectrum analyzer VBW shall be equal to or greater than the RBW. Empirical or calculated bandwidth correction factors shall be used to adjust the measurement of the UWB waveform to the IF bandwidth of the receiver. Average measurements shall be made for all of the test waveforms except for Waveform 5 which shall be made as a peak measurement. Record the interfering signal conditions (signal parameters and levels) that cause an impact on the receiver output.

5.5 Receiver Susceptibility – Missed Interrogation - High Level UWB Signal

5.5.1 Receiver Susceptibility – Missed Interrogation - High Level UWB Signal Test Objective

The objective of this test is to determine the impact of a high level UWB interfering signal on an IFF transponder. The tests shall determine the desired signal level that is required for the receiver to operate in a satisfactory manner with a high level UWB interfering signal (e.g., 40 dB above the receiver sensitivity) present.

5.5.2 Receiver Susceptibility – Missed Interrogation - High Level UWB Signal Test Setup

The test setup is basically the same as the setup shown in Figure 3. The only differences between this test and the previous test (i.e., the two signal test with the desired signal set at a standard response level) are the levels of the desired and interfering signals.

5.5.3 Receiver Susceptibility – Missed Interrogation - High Level UWB Signal Test Procedure

The test procedure for determining the desired signal level required for satisfactory operation when a high level interfering signal is present as follows:

21. Set the interrogator to one of the modes of operation. Select a UWB signal waveform.

22. Adjust the UWB signal so the inband components of the UWB signal (i.e., the UWB components measured in a bandwidth equal to the IF bandwidth of the receiver or adjusted to the IF bandwidth by using a bandwidth correction factor) are 40 dB above the receiver sensitivity or are at the maximum power available from the pulse generator %). Record this level as the Interference Signal Level (ISL) in dBm.

NOTE: The spectrum analyzer resolution bandwidth will not be as wide as the RF bandwidth of the IFF receiver, 9.8 MHz. The average noise level shall be measured using the spectrum analyzer with a RBW of 1 MHz (or greatest available spectrum analyzer RBW equal to or less than the IFF IF passband). The spectrum analyzer VBW shall be equal to or than RBW. Empirical or calculated bandwidth correction factors shall be used to adjust the readings to the IF bandwidth of the receiver.

23. Increase the desired signal level until the receiver achieves a standard response condition. Record the desired signal level for acquisition of the standard response condition (ACQ) on the appropriate line for the selected UWB waveform and IFF mode in Table 5. On the same line calculate the Interference-to-Signal Ratio (I/S) as ISL – ACQ.

24. Decrease the desired signal level until upset occurs. Record the desired signal level for upset of the standard response condition (SUPSET) on the appropriate line for the selected UWB waveform and IFF mode in Table 5. On the same line calculate the Interference-to-Signal Ratio (I/S) as ISL – SUPSET.

25. Repeat Steps 1 through 4 for each of the UWB waveforms.

26. Repeat Steps 1 through 5 for each unclassified IFF mode.

5.5.4 Receiver Susceptibility – Missed Interrogation - High Level UWB Signal Test Output

Record the interfering signal level (ISL), the desired signal levels for the conditions where "acquisition" (ACQ) and "upset" (SUPSET) occurred and the signal to interference ratios (S/I) on the appropriate lines on the applicable data sheet provided in Table 5.

TABLE 5
RECEIVER SUSCEPTIBILITY – MISSED INTERROGATION - HIGH LEVEL UWB SIGNAL

Receiver: AN/APX-100
Frequency Band: 1030 MHz
Test Frequencies: 1030 MHz
Receiver Mode: 1, 2, 3A, 3C, 4 (Circle applicable mode)
Standard Response Criterion: 90% Reply Rate
Desired Signal Modulation: PPM
Sensitivity: - 77 dBm

RX FRQ (MHz)	UWB SIGNAL	PRF (MHz)	UWB MOD	ISL (dBm)	ACQ (dBm)	SUPSET (dBm)	I/S (dB)
1030	1	93.6	NONE			X	
1030	1	93.6	NONE		X		
1030	2	93.6	DITHERED ± 5%			X	
1030	2	93.6	DITHERED ± 5%		X		
1030	3	9.8	DITHERED ± 25%			X	
1030	3	9.8	DITHERED ± 25%		X		
1030	4	9.8	PPM			X	
1030	4	9.8	PPM		X		
1030	5	0.980	NONE			X	
1030	5	0.980	NONE		X		

NOTE: The spectrum analyzer resolution and video bandwidths will not be as wide as the RF bandwidth of the UWB waveform. The RBW of the spectrum analyzer shall be 1 MHz or the spectrum analyzer RBW closest to, but not exceeding, 9.8 MHz. The spectrum analyzer VBW shall be equal to or greater than the RBW. Empirical or calculated bandwidth correction factors shall be used to adjust the measurement of the UWB waveform to the IF bandwidth of the receiver. Average measurements shall be made for all of the test waveforms except for Waveform 5 which shall be made as a peak measurement. Record the interfering signal conditions (signal parameters and levels) that cause an impact on the receiver output.

APPENDIX H
AUGUST 16, 2002
UWB EMI TEST PLAN FOR THE AN/APN-194(V) SYSTEM

1.0 INTRODUCTION

The AN/APN-194(V) Radar Altimeter system provides electronic altitude measurement for aircraft at altitudes of 5000 feet (5 kft) or below. The system consists of a single receiver-transmitter (RT), RT-1015A/APN-194(V), and two antennas. The system transmits one of two very short pulses, 200 ns or 20 ns, depending on aircraft altitude and measures the time until the pulse echo is returned from the surface of the ground or water below and provides an altitude reading to the pilot. The radar pulse repetition frequency (PRF) is 22 thousand pulses per second (kpps)

The AN/APN-194(V) is a homodyne system operating at approximately 4300 MHz. The AN/APN-194(V) receiver 3 dB bandwidth is 30 MHz, 20 dB bandwidth is 80 MHz, and 60 dB bandwidth is 200 MHz. It has a nominal sensitivity of –83 dBm, the minimum detectable signal (MDS).

The AN/APN-194(V) has two modes of operation:

- Short pulse mode, 20 ns pulse width (PW), is used at altitudes of one thousand feet (1 kft) and below.

- Long pulse mode, 200 ns PW, is used at all other altitudes.

2.0 OVERALL TEST OBJECTIVE

In order to accomplish the test objective, there are several parameters that must be measured. These parameters are the sensitivity of the receiver to the desired signal and the susceptibility of the receiver to typical UWB interfering signals. The test shall be performed with the AN/APN-194(V) receiver operating in various modes.

The tests shall be performed by personnel that are familiar with EMI test equipment and are knowledgeable about EMI test procedures and techniques. The test personnel that shall be performing the tests work at the Naval Air Warfare Center Aircraft Division (NAWC AD) Aircraft Intermediate Maintenance Division (AIMD) facility where the tests shall be performed. These personnel are experienced EMI testing specialists. For the type of scientific testing required for this project, detailed "cookbook" test procedures may be too restrictive and may impede testing. Therefore, detailed test procedures are not considered to be necessary and shall not be provided in the test plan.

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3.0 TEST APPROACH

In order to accomplish the test objective, there are several parameters that must be measured. These parameters are the sensitivity of the receiver to the desired signal and the susceptibility of the receiver to typical UWB interfering signals. The test shall be performed with the AN/APN-194(V) receiver operating in various modes.

4.0 UWB WAVEFORMS

The UWB waveform parameters that shall be used for the AN/APN-194(V) receiver shall be selected from the set of waveforms that are presented below. When a filtered waveform is used, the 4,200 MHz to 4,400 MHz filter for the UWB signal shall be selected so the UWB operating band falls across the AN/APN-194(V) receive band, 4,200 MHz to 4,400 MHz. When the waveform is generated by a baseband pulse, the selection of the frequency band does not apply.

The five waveforms described below should provide the most EMI impact that a UWB waveform should have on an AN/APN-194(V) receiver. UWB Test Waveforms Six (TW6) and Seven (TW7) are not applicable to the AN/APN-194(V).

4.1 Test Waveform One (TW1)

For the first test waveform, the pulse repetition frequency (PRF) of the UWB signal shall be the maximum value available from the pulse generator that results in the fundamental or one harmonic of the UWB PRF falling within the operating range of the AN/APN-194(V) receiver, 4,285 to 4,315 MHz. Since the maximum PRF available from the pulse generator is 100 MHz, 100 MHz shall be used. The 43rd harmonic of 100 MHz is 4,300 MHz which is the center frequency of the receiver 3 dB passband. The 42nd harmonic at 4,200 MHz and the 44th harmonic at 4,400 MHz will be just on the edges of the receiver's 60 dB bandpass and may affect the receiver's response to the UWB interference. This first test waveform shall not be dithered or modulated. This should result in either the appearance of a steady interference signal in the receiver or an interference tone with a low level amplitude modulated (AM) modulation at 100 MHz.

4.2 Test Waveform Two (TW2)

For the second test waveform, the basic PRF of the UWB signal shall be the same as that described for the first test waveform (i.e., 100 MHz) but the pulses shall be randomly dithered ± 50 %. At the receiver frequency, the interference signal from the 43rd harmonic will be varying from 4,250 to 4,350 MHz, a slightly larger bandwidth than the receiver 20 dB bandwidth; however, both the 42nd and 44th harmonics will also be varying ± 50 MHz in the same pattern as the 43rd harmonic. This should result in a noise-like signal filling the receiver intermediate frequency (IF) passband.

4.3 Test Waveform Three (TW3)

For the third test waveform, the PRF of the UWB signal shall be equal to the IF bandwidth of the receiver, 30 MHz, and the pulses shall not be modulated. The 143rd harmonic of 30 MHz is 4,290 MHz, 10 MHz below the center of the receiver 3 dB passband. The 144th harmonic is 4,320 MHz, 5 MHz above the 3 dB corner of the receiver passband but well within the 20 dB passband Harmonics 142 through 144 fall within the receiver's 20 dB passband, and harmonics 140through 146 fall within the receiver's 20 dB passband. This will result in a single spectral component in the IF 3dB passband, which would normally result in a an interference pattern similar to a steady tone; but the presence of seven (7) similar spectral lines, all at different attenuations will probably result in an interference pattern similar to an amplitude modulated (AM) tone with a 30 MHz modulation frequency.

4.4 Test Waveform Four (TW4)

For the fourth test waveform, the PRF of the UWB signal shall be equal to the receiver IF bandwidth, 30 MHz, and the signal shall be dithered ± 25 %. Each of the lines described in Section 4.3 above will be 15 MHz wide and appear noise-like. This shall result in a noise-like signal in the IF passband.

4.5 Test Waveform Five (TW5)

For the fifth test waveform, the PRF of the UWB signal should be 0.1 times the receiver IF bandwidth. Therefore, the PRF of the UWB should be 3 MHz, and the signal shall be modulated as 10% duty cycle bursts with a 22 kpps rate in a fashion similar to an actual AN/APN-194(V) radar pulse. This type of interfering signal shall result in a modulated signal in the IF passband

5.0 RECEIVER SUSCEPTIBILITY TEST

The objective of the receiver susceptibility tests is to obtain data that will provide useful information on the susceptibility of AN/APN-194(V) receivers to UWB interference. The tests will be performed using either one or two signals. With the one signal tests, a UWB interfering signal is input to the receiver under test and the output is observed. The receiver is considered to be susceptible if the UWB interfering signal produces a detectable change in the receiver output. No intended in-band signal is used for this test. For the AN/APN-194(V) receiver, the concern is that EMI may cause false returns that will result in incorrect altitude readings.

The two signal susceptibility tests described in this test plan require that the receiver desired signal and a UWB interfering signal be simultaneously injected into the receiver antenna port. The concern is that EMI can cause the AN/APN-194(V) receiver to miss ground returns or incorrectly identify returns resulting in a flat altitude reading. The AN/APN-194(V) standard response is the radar's MDS, a ground return signal level of -83 dBm or greater. The MDS provides the basis for these susceptibility tests. The sensitivity is measured before the susceptibility tests are performed.

There are two approaches that may be used for the two signal susceptibility tests. For the first approach, the desired signal level is fixed at a level that is 6 dB above the “standard response acquisition threshold” (ACQ). The receiver susceptibility to UWB interference is determined by slowly increasing the UWB signal strength until the receiver can no longer maintain a standard response. The UWB interference level that degrades the receiver below the standard response condition is referred to as the Interference Upset Level (IUPSET). The UWB interfering signal is then increased to 20 dB above the Upset Level and slowly reduced until the standard response is reestablished. The level of the UWB interfering signal at which the standard response is reestablished is the Reacquisition Level (REACQ). These levels describe the effect of the UWB interfering signal when the desired signal is close to the standard response threshold.

For the second approach, a high level UWB interfering signal (e.g., 20 dB above the receiver sensitivity) is injected and the desired signal level that is required for satisfactory operation of the receiver is determined. The information obtained from this test may be used to determine the reduction in range that the receiver will experience as a result of UWB interference. These levels are a better indication of the degradation resulting from UWB interference when the receiver has significant desired signal to operate with and is more typical of normal operations.

5.1 Receiver Sensitivity Measurement

The receiver sensitivity level is specified as the signal level required to create an appropriate standard response that results in satisfactory operation of the receiver. The degradation criteria for AN/APN-194(V) systems are based on the system’s ability to detect the simulated ground echo and correctly determine the simulated aircraft altitude. The AN/APN-194(V) minimum detectable signal (MDS) level is based on a 1 dB signal to interference, noise, and distortion (SINAD). The nominal receiver MDS is –83 dBm.

5.2.1 Receiver Sensitivity Measurement Objective

The objective of this test is to determine the standard response level, (i.e., the input signal level that is required for the AN/APN-194(V) receiver to achieve a 1 dB signal to interference, noise, and distortion [SINAD]).

5.1.2 Receiver Sensitivity Measurement Test Setup

The test set-up for the receiver sensitivity measurement is shown in Figure 1. An AN/APN-194(V) test set (AN/APM-403) is used to generate the interrogation signal. A spectrum analyzer is used to monitor and measure the signal levels at the input to the AN/APN-194(V) receiver under test. A pre-amplifier connected at the input of the spectrum analyzer may be required to observe the signal during the sensitivity test. Alternatively, after the sensitivity level is established, the signal level can be raised by a known, fixed amount (e.g., 40 dB) to enable the spectrum analyzer measurement to be made.

Spectrum analyzer levels shall be corrected for the pre-amplifier gain (if used) plus coupler and/or cable losses that exist in the measurement system. The AN/APX–194(V) receiver operation is verified to be satisfactory by monitoring the receiver output as displayed on the AN/APM-403 to ensure that the interrogation reply rate is at least 90%.

5.1.3 Receiver Sensitivity Test Procedure

The AN/APN-194(V) shall be tested in each of the modes listed in Section 1.0 above. The general test procedure for determining receiver sensitivity for operation in a fixed frequency mode is as follows:

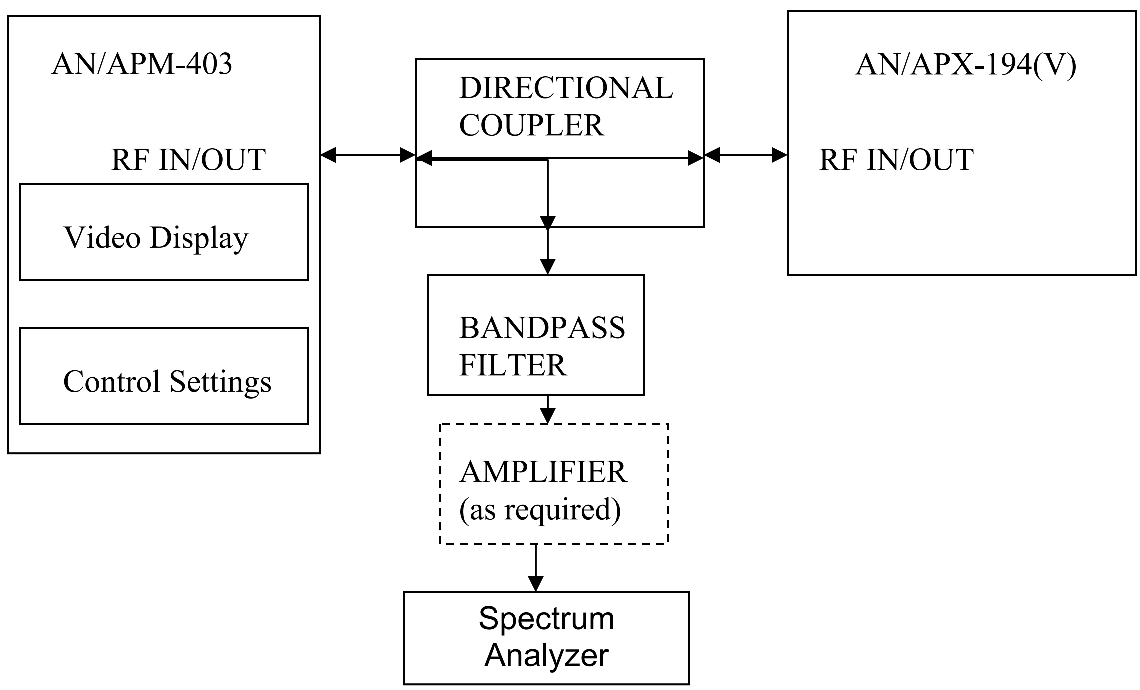


Figure 1. Receiver Sensitivity Test Set-Up

37. Connect the AN/APN-194(V) to the AN/APM-403 in accordance with normal test procedures as modified in Figure 1. Set AN/APM-403 to the desired mode and adjust for minimum power output. Verify that the receiver has not achieved a standard response condition for the low level signal.

38. Increase the AN/APM-403 output power level until the AN/APM-403 output monitor indicates a reply rate of 90%. Be sure to pause between each increase in

signal power by an amount exceeding the maximum specified settling time for the receiver. Record the input power level at which the "standard response acquisition threshold" (ACQ) (i.e., -83 dBm MDS) was first observed on the data sheet in Table 1.

39. Increase the input power level an additional 10 dB above ACQ. This should result in a reply rate greater than 90%.

40. Decrease the input power until the reply rate drops below 90%. Record this level as the signal upset (SUPSET) threshold on the data sheet in Table 1.

41. Repeat steps 1 through 4 for each mode of operation.

TABLE 1
DATA SHEET FOR SENSITIVITY MEASUREMENTS

Receiver: AN/APN-194(V)
Frequency Band: 4300 MHz
Receiver Modes: Long Pulse, Short Pulse
Test Frequencies: 4300 MHz
Standard Response Criterion: -83 dBm MDS
Desired Signal Modulation: PPM
IF Bandwidth: 30 MHz
Sensitivity: -83 dBm

RCVR FRQ (MHz)	**RCVR MODE**	**ACQ (dBm)**	**SUPSET (dBm)**	**NOTES (Record ACQ and SUPSET for each measurement here and average in column at left)**
4300	Long Pulse			
4300	Short Pulse			

NOTE: Sensitivity threshold levels are inherently statistical and thus this procedure shall be conducted multiple times to obtain a representative sample of the threshold level.

NOTE: Because the receive and the transmit signals use the same antenna, but at different frequencies, it shall be necessary to isolate the test instrumentation from the effects of the transmit signal. This is best done through a combination of a single direction directional coupler and a very narrow band bandpass filter tuned to the AN/APN-194(V) interrogation frequency, 4300 MHz. The 3 dB bandwidth of the filter shall be less than or equal to 1 MHz, but greater than or equal to 30 MHz in order to allow the full interrogation signal to pass. The filter's signal rejection at the AN/APN-194(V) AN/APN-194(V) receiver frequency, 1090 MHz, shall be greater than or equal to 60 dB. If an amplifier is required, the gain shall be at least 10 dB greater than the attenuation of the directional coupler in order to get the minimum AN/APN-194(V) interrogation signal above the spectrum analyzer noise floor, typically -80 dBm/MHz.

5.1.4 Receiver Sensitivity Measurement Output

The required results from the Receiver Sensitivity Test consist of documenting the "standard response acquisition threshold" (ACQ) and the signal upset (SUPSET) threshold on the appropriate line of the data sheet provided in Table 1. An average threshold value shall be specified if significant differences exist between the thresholds determined for each of the interrogation modes.

5.3 Receiver Susceptibility To White Noise

5.2.1 Receiver Susceptibility To White Noise Test Objective

The objective of this EMI test is to determine the susceptibility of an AN/APN-194(V) receiver (operating with a desired signal at the standard response level) to white noise interference. Susceptibility thresholds shall be determined by monitoring the output of the receiver and measuring the standard response level.

5.2.2 Receiver Susceptibility To White Noise Test Setup

The test setup is shown in Figure 2.

5.2.3 Receiver Susceptibility To White Noise Test Procedure

The general test procedure for determining receiver susceptibility to interference when the desired signal is at the standard response level and the receiver is operating at a fixed frequency is as follows:

35. Set the AN/APM-403 to the ACQ level for the appropriate mode shown in Table 1.

36. Activate the white noise source at a level that is at least 10 dB below the SUPSET level for the appropriate mode shown in Table 1. If interference to the desired signal is observed, reduce the white noise level to 10 dB below the lowest level at which interference is noted or maximum attenuation.

37. Slowly increase the white noise power level until there is an indication of impact on the receiver standard response condition (i.e., a decrease in the Reply Response %). Note that the spectrum analyzer resolution bandwidth will not be as wide as the RF bandwidth of the AN/APN-194(V) receiver, 30 MHz . The

average noise level shall be measured using the spectrum analyzer with a resolution bandwidth (RBW) of 1 MHz (or greatest available spectrum analyzer RBW equal to or less than the AN/APN-194(V) IF passband). The spectrum analyzer Video Bandwidth [VBW] shall be equal to or greater than RBW. Empirical or calculated bandwidth correction factors shall be used to adjust the readings to the IF bandwidth of the receiver. Record this level as the "desired signal upset threshold" (WNUPSET) level in Table 2.

38. Increase the white noise level at least 10 dB above the WNUPSET level.

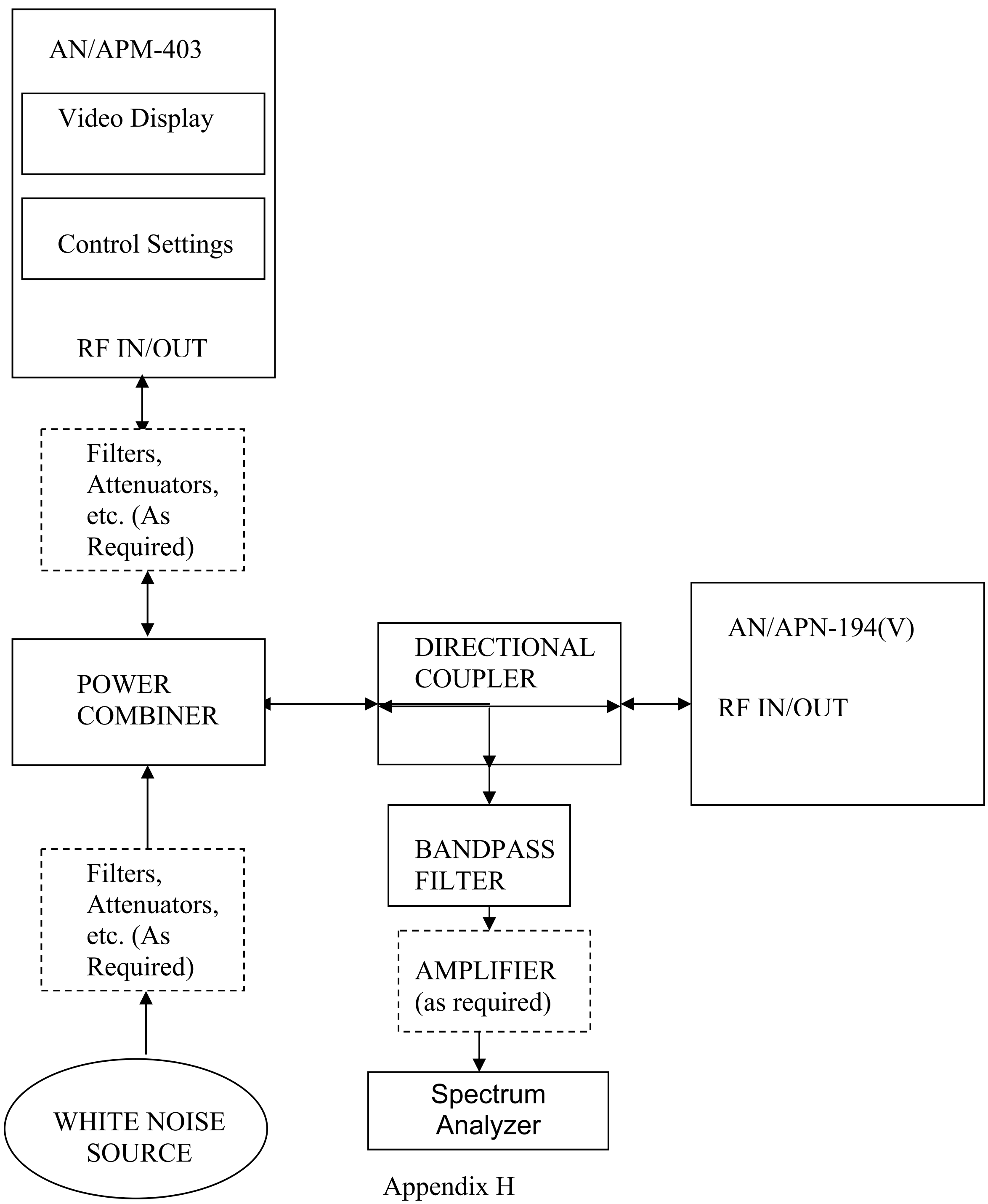


Figure 2. Conducted Susceptibility Test Set-Up-Two Signal Method

39. Slowly decrease the white noise level until the receiver reachieves the standard response condition. Record this level as the reacquisition threshold (WNREACQ) level. This level may be the same as WNUPSET.

40. Repeat Steps 1 through 5 for each different receiver operating mode.

TABLE 2
DATA SHEET FOR WHITE NOISE TESTS

Receiver: AN/APN-194(V)
Frequency Band: 4300 MHz
Receiver Mode: Long Pulse, Short Pulse (Circle applicable mode)
Test Frequencies: 4300 MHz
Standard Response Criterion: -83 dBm MDS
Desired Signal Modulation: PPM
Sensitivity: -83 dBm

	SIGNAL LEVEL (dBm)	**NOISE LEVEL (dBm)**
ACQ		**N/A**
WNUPSET		
WNREACQ		

5.2.4 Receiver Susceptibility To White Noise Test Output

The required results from the Receiver Susceptibility To White Noise Test consist of documenting the "standard response acquisition threshold" (ACQ), the "desired signal upset threshold" (WNUPSET) and the reacquisition threshold (WNREACQ) on the appropriate lines of the data sheet provided in Table 2 for the appropriate AN/APN-194(V) mode.

5.3 One Signal Receiver Susceptibility – False Interrogations

5.3.1 One Signal Receiver Susceptibility – False Interrogations Test Objective

The objective of this test is to determine the impact of a UWB interfering signal to creating false interrogations in the receiver that shall result in false replies.

5.3.2 One Signal Receiver Susceptibility – False Interrogations Test Setup

The test setup is the same as the one shown in Figure 3. However, the test set is not interrogating on any of the AN/APN-194(V) Modes.

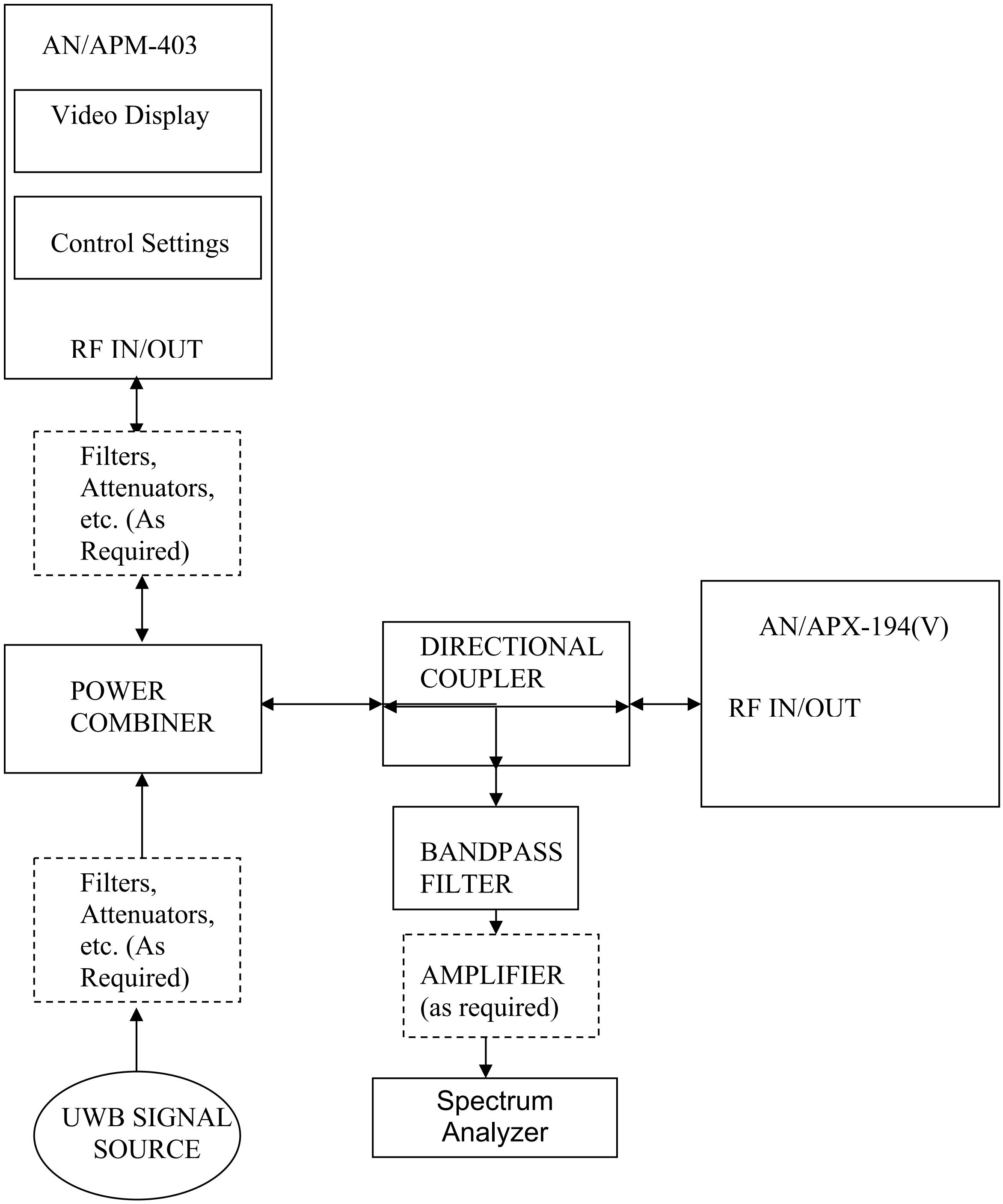
5.3.3 One Signal Receiver Susceptibility – False Interrogations Test Procedures

6. Set the interrogator so it is not interrogating any of the AN/APN-194(V) Modes. If necessary, turn the interrogator OFF.

7. Activate the UWB interference signal source with the first UWB test waveform at a maximum power level.

8. Monitor the output of the AN/APN-194(V) receiver and note if there are any false replies.

Figure 3. Conducted Susceptibility Test Set-Up-Two Signal Method



9. If there are any false replies, reduce the level of the UWB interfering signal until there are no false replies. Record this as the "False Reply Interference Threshold" (FRIT) in Table 3.

10. Repeat Steps 1 through 4 for the other UWB waveforms.

TABLE 3
DATA SHEET FOR ONE SIGNAL SUSCEPTIBILITY TEST

Receiver: AN/APN-194(V)
Frequency Band: 4300 MHz
Receiver Mode: Long Pulse, Short Pulse (Circle applicable mode)
Test Frequencies: 4300 MHz
Standard Response Criterion: -83 dBm MDS
Desired Signal Modulation: PPM
IF Bandwidth: 30 MHz
Sensitivity: -83 dBm

RX FRQ (MHz)	UWB SIGNAL	PRF (MHz)	UWB MOD	FRIT (dBm)
4300	1	93.6	NONE	
4300	2	93.6	DITHERED ± 5%	
4300	3	9.8	DITHERED ± 25%	
4300	4	9.8	PPM	
4300	5	0.980	NONE	

Note that the spectrum analyzer resolution and video bandwidths will not be as wide as the RF bandwidth of the UWB waveform. The resolution bandwidth (RBW) of the spectrum analyzer shall be 1 MHz or the spectrum analyzer RBW closest to, but not exceeding, 30 MHz . The spectrum analyzer video bandwidth (VBW) shall be equal to or grater than the RBW. Empirical or calculated bandwidth correction factors shall be used to adjust the measurement of the UWB waveform to the IF bandwidth of the receiver. Average measurements shall be made for all of the test waveforms except for Waveform 5 which shall be made as a peak measurement. Record the interfering signal conditions (signal parameters and levels) that cause an impact on the receiver output.

5.3.4 One Signal Receiver Susceptibility – False Interrogations Test Output

The required results from the One Signal Receiver Susceptibility – False Interrogations Test consist of documenting the "False Reply Interference Threshold" (FRIT) on the appropriate lines of the data sheet provided in Table 3 for the appropriate AN/APN-194(V) mode.

5.4 Receiver Susceptibility- Missed Interrogations - Standard Response Desired Signal

5.4.1 Receiver Susceptibility- Missed Interrogations - Standard Response Desired Signal Test Objective

The objective of this EMI test is to determine the susceptibility of an AN/APX-100(V) receiver (operating with a desired signal at the standard response level) to UWB interfering signals. Susceptibility thresholds shall be determined by monitoring the output of the receiver and measuring the standard response level.

5.4.2 Receiver Susceptibility- Missed Interrogations - Standard Response Desired Signal Test Setup

The test setup is shown in Figure 3.

5.4.3 Receiver Susceptibility- Missed Interrogations - Standard Response Desired Signal Test Procedure

The general test procedure for determining receiver susceptibility to interference when the desired signal is at the standard response level is as follows:

8. Set the interrogator to the selected test mode and adjust output power level to 6 dB above the ACQ level recorded in Table 1. Decreased the desired signal to a level the "desired signal upset threshold" (SUPSET) recorded in Table 1. Record this level as the Desired Signal Level (DSL) in Table 4 for the specified UWB waveform. Verify that the receiver output exceeds the standard response condition (i.e. -83 dBm MDS).

9. Activate the UWB interference signal source with one of the UWB test waveforms as a level that is at least 20 dB below SUPSET.

NOTE: The spectrum analyzer resolution bandwidth will not be as wide as the RF bandwidth of the AN/APN-194(V) receiver, 30 MHz . The average noise level shall be measured using the spectrum analyzer with a resolution bandwidth (RBW) of 1 MHz (or greatest available spectrum analyzer RBW equal to or less than the AN/APN-194(V) IF passband). The spectrum analyzer Video Bandwidth [VBW] shall be equal to or greater than RBW. Empirical or calculated bandwidth correction factors shall be used to adjust the readings to the IF bandwidth of the receiver.

10. Increase the UWB interference signal power level until there is an indication of impact on the receiver standard response condition (i.e., a decrease in the reply rate). Record this level as the "interfering signal upset threshold" (IUPSET) level in Table 4. Record IUPSET – DSL as the interference-to-signal ratio (I/S).

11. Adjust the desired signal level to 6 dB above the ACQ level recorded in Table 1. Record this level as the "desired signal level" (DSL) on the second row for the selected UWB waveform.

12. Set the UWB interfering signal to the maximum level available. If the standard response condition is impacted, slowly decrease the UWB interference signal power until the receiver returns to a standard response. Record this interference level in Table 4 as the "interfering signal reacquisition threshold" (REACQ) level. Record REACQ – DSL as the I/S ratio in Table 4.

13. Repeat Steps 1 through 5 for each UWB waveform.

14. Repeat Steps 1 through 6 for each AN/APN-194(V) operating mode.

5.4.4 Receiver Susceptibility- Missed Interrogations - Standard Response Desired Signal Test Output

The required results from the two signal EMI tests consist of recording the desired signal level for the "standard response acquisition threshold," the "desired signal upset threshold," and calculating the difference between these levels as the Interference-to-Signal Ratio (I/S). Also, the interfering signal level for the "interfering signal upset threshold," the "reacquisition threshold," and the calculated the difference between these levels as the Interference-to-Signal Ratio (I/S) shall be recorded on the appropriate lines of the applicable data sheet for the interference signal modulations and receiver mode of operation.

TABLE 4
RECEIVER SUSCEPTIBILITY- MISSED INTERROGATIONS - STANDARD RESPONSE DESIRED SIGNAL

Receiver: AN/APN-194(V)
Frequency Band: 4300 MHz
Test Frequencies: 4300 MHz
Receiver Mode: Long Pulse, Short Pulse (Circle applicable mode)
Standard Response Criterion: -83 dBm MDS
Desired Signal Modulation: PPM
Sensitivity: - 77 dBm

RX FRQ (MHz)	UWB SIGNAL	PRF (MHz)	UWB MOD	DSL (dBm)	IUPSET (dBm)	REACQ (dBm)	I/S (dB)
4300	1	93.6	NONE			X	
4300	1	93.6	NONE		X		
4300	2	93.6	DITHERED ± 5%			X	
4300	2	93.6	DITHERED ± 5%		X		
4300	3	9.8	DITHERED ± 25%			X	
4300	3	9.8	DITHERED ± 25%		X		

RX FRQ (MHz)	UWB SIGNAL	PRF (MHz)	UWB MOD	DSL (dBm)	IUPSET (dBm)	REACQ (dBm)	I/S (dB)
4300	4	9.8	PPM			X	
4300	4	9.8	PPM		X		
4300	5	0.980	NONE			X	
4300	5	0.980	NONE		X		

Note that the spectrum analyzer resolution and video bandwidths will not be as wide as the RF bandwidth of the UWB waveform. The resolution bandwidth (RBW) of the spectrum analyzer shall be 1 MHz or the spectrum analyzer RBW closest to, but not exceeding, 30 MHz . The spectrum analyzer video bandwidth (VBW) shall be equal to or grater than the RBW. Empirical or calculated bandwidth correction factors shall be used to adjust the measurement of the UWB waveform to the IF bandwidth of the receiver. Average measurements shall be made for all of the test waveforms except for Waveform 5 which shall be made as a peak measurement. Record the interfering signal conditions (signal parameters and levels) that cause an impact on the receiver output.

5.5 Receiver Susceptibility – Missed Interrogation - High Level UWB Signal

5.5.1 Receiver Susceptibility – Missed Interrogation - High Level UWB Signal Test Objective

The objective of this test is to determine the impact of a high level UWB interfering signal on an AN/APN-194(V) AN/APN-194(V) receiver. The tests shall determine the desired signal level that is required for the receiver to operate in a satisfactory manner with a high level UWB interfering signal (e.g., 40 dB above the receiver sensitivity) present.

5.5.2 Receiver Susceptibility – Missed Interrogation - High Level UWB Signal Test Setup

The test setup is basically the same as the setup shown in Figure 3. The only differences between this test and the previous test (i.e., the two signal test with the desired signal set at a standard response level) are the levels of the desired and interfering signals.

5.5.3 Receiver Susceptibility – Missed Interrogation - High Level UWB Signal Test Procedure

The test procedure for determining the desired signal level required for satisfactory operation when a high level interfering signal is present is as follows:

27. Set the interrogator to one of the modes of operation. Select a UWB signal waveform.

28. Adjust the UWB signal so the inband components of the UWB signal (i.e., the UWB components measured in a bandwidth equal to the IF bandwidth of the receiver or adjusted to the IF bandwidth by using a bandwidth correction factor) are 40 dB above the

receiver sensitivity or are at the maximum power available from the pulse generator. %). Record this level as the Interference Signal Level (ISL) in dBm.

NOTE: The spectrum analyzer resolution bandwidth will not be as wide as the RF bandwidth of the AN/APN-194(V) receiver, 30 MHz . The average noise level shall be measured using the spectrum analyzer with a resolution bandwidth (RBW) of 1 MHz (or greatest available spectrum analyzer RBW equal to or less than the AN/APN-194(V) IF passband). The spectrum analyzer Video Bandwidth [VBW] shall be equal to or greater than RBW. Empirical or calculated bandwidth correction factors shall be used to adjust the readings to the IF bandwidth of the receiver.

29. Increase the desired signal level until the receiver achieves a standard response condition. Record the desired signal level for acquisition of the standard response condition (ACQ) on the appropriate line for the selected UWB waveform and AN/APN-194(V) mode in Table 5. On the same line calculate the Interference-to-Signal Ratio (I/S) as ISL – ACQ.

30. Decrease the desired signal level until upset occurs. Record the desired signal level for upset of the standard response condition (SUPSET) on the appropriate line for the selected UWB waveform and AN/APN-194(V) mode in Table 5. On the same line calculate the Interference-to-Signal Ratio (I/S) as ISL – SUPSET.

31. Repeat Steps 1 through 4 for each of the UWB waveforms.

32. Repeat Steps 1 through 5 for each unclassified AN/APN-194(V) mode.

5.5.4 Receiver Susceptibility – Missed Interrogation - High Level UWB Signal Test Output

Record the interfering signal level (ISL), the desired signal levels for the conditions where "acquisition" (ACQ) and "upset" (SUPSET) occurred and the signal to interference ratios (S/I) on the appropriate lines on the applicable data sheet provided in Table 5.

TABLE 5
RECEIVER SUSCEPTIBILITY – MISSED INTERROGATION - HIGH LEVEL UWB SIGNAL

Receiver: AN/APN-194(V)
Frequency Band: 4300 MHz
Test Frequencies: 4300 MHz
Receiver Mode: Long Pulse, Short Pulse (Circle applicable mode)
Standard Response Criterion: -83 dBm MDS
Desired Signal Modulation: PPM
Sensitivity: - 77 dBm

RX FRQ (MHz)	UWB SIGNAL	PRF (MHz)	UWB MOD	ISL (dBm)	ACQ (dBm)	SUPSET (dBm)	I/S (dB)
4300	1	93.6	NONE			X	
4300	1	93.6	NONE		X		
4300	2	93.6	DITHERED ± 5%			X	
4300	2	93.6	DITHERED ± 5%		X		
4300	3	9.8	DITHERED ± 25%			X	
4300	3	9.8	DITHERED ± 25%		X		
4300	4	9.8	PPM			X	
4300	4	9.8	PPM		X		
4300	5	0.980	NONE			X	
4300	5	0.980	NONE		X		

Note that the spectrum analyzer resolution and video bandwidths will not be as wide as the RF bandwidth of the UWB waveform. The resolution bandwidth (RBW) of the spectrum analyzer shall be 1 MHz or the spectrum analyzer RBW closest to, but not exceeding, 30 MHz . The spectrum analyzer video bandwidth (VBW) shall be equal to or grater than the RBW. Empirical or calculated bandwidth correction factors shall be used to adjust the measurement of the UWB waveform to the IF bandwidth of the receiver. Average measurements shall be made for all of the test waveforms except for Waveform 5 which shall be made as a peak measurement. Record the interfering signal conditions (signal parameters and levels) that cause an impact on the receiver output.

APPENDIX I
UWB EMI TEST PLAN FOR THE AN/ARN-118 (V) TACAN SYSTEM

1.0 INTRODUCTION

The AN/ARN-118 (V) Tactical Air Navigation (TACAN) system provides distance and bearing (azimuth) information for aircraft. The system consists of an airborne interrogator that transmits timed pulse pairs and a ground or shipboard transponder that receives the interrogation and decodes the interrogation pulses. If the code is correct, the transponder, after a 50 microsecond delay, automatically transmits a coded reply which is offset 63 MHZ from the transponder frequency. The airborne receiver measures the round trip time and calculates the distance from the transponder.

In principle, the TACAN transponder needs to reply at only 30 pulse pairs per second per airborne equipment to supply the necessary distance data. However, the total pulse output of the transmitter would constantly vary according to the number of aircraft. In addition, random noise or EMI may trigger the transponder.

For the transponder to provide azimuth information, the average power supplied to the antenna must be relatively uniform over time. To accomplish this, the transponder is operated on the constant duty cycle principle. In this method of operation, the receiver uses automatic gain and squitter controls to maintain a constant pulse output. If only a few interrogations are being received, the gain and squitter of the receiver increase and add noise generated pulses to the pulse train. If more interrogations are received, the gain and squitter decrease and reduce the number of noise generated pulses.

In order to provide azimuth information, the transponder produces a directional antenna pattern that rotates around a vertical axis. This signal, when properly referenced indicates the aircraft direction (i.e. azimuth) relative to the TACAN facility.

The TACAN receiver operates in the frequency range from 962 MHz to 1213 MHz. The tests shall be conducted at 987.1 MHz, 1087.5 MHz and 1187.9 MHz. The sensitivity of the TACAN receiver is –89 dBm and the intermediate frequency (IF) bandwidth is 0.40 MHz.

2.0 OVERALL TEST OBJECTIVE

The overall objective of the test is to determine the EMI susceptibility of the TACAN to conducted ultra-wideband (UWB) signals that are injected into the receiver antenna port. The results of this investigation shall provide the information necessary to evaluate the potential for UWB signals to interfere with the TACAN and to understand how UWB systems could be implemented to make use of their unique capabilities without causing electromagnetic interference (EMI).

3.0 TEST APPROACH

In order to accomplish the test objective, there are several parameters that must be measured. These parameters are the sensitivity of the receiver to the desired signal and the susceptibility of the receiver to typical UWB interfering signals. The test shall be performed with the TACAN receiver operating at several different frequencies.

The tests shall be performed by personnel that are familiar with EMI test equipment and are knowledgeable about EMI test procedures and techniques. The test personnel that shall be performing the tests work at the Naval Air Warfare Center Aircraft Division (NAWC AD) Aircraft Intermediate Maintenance Division (AIMD) facility where the tests shall be performed. These personnel are experienced EMI testing specialists. For the type of scientific testing required for this project, detailed "cookbook" test procedures may be too restrictive and may impede testing. Therefore, detailed test procedures are not considered to be necessary and shall not be provided in the test plan.

4.0 UWB WAVEFORMS

The UWB waveform parameters that shall be used for the AN/ARN-118(V) receiver shall be selected from the set of waveforms that are presented below. When a filtered waveform is used, the 950 MHz to 1,250 MHz filter for the UWB signal shall be selected so the UWB operating band falls across the AN/ARN-118(V) receive band, 962 MHz to 1213 MHz. When the waveform is generated by a baseband pulse, the selection of the frequency band does not apply.

The first five waveforms described below shall provide the most EMI impact that a UWB waveform shall have on an TACAN receiver. If there is no EMI impact with any of the first five waveforms, there probably shall not be any impact with any of the other waveforms and the testing can end at this point. If any of the first five waveforms have an EMI impact, further testing is required to better characterize the impact. The tests shall be performed using the waveform parameters defined below.

4.1 Test Waveform One (TW1)

For the first test waveform, the pulse repetition frequency (PRF) of the UWB signal shall be the maximum value available from the pulse generator that results in the fundamental or one harmonic of the UWB PRF falling within the operating range of the AN/ARN-118(V) receiver. The AN/ARN-118 (V) receiver tunes in 1MHz steps. Therefore, the test frequencies shall be 987 MHz, 1087 MHz and 1188 MHz. The PRF for the first test frequency shall be 98.7 MHz which will result in a tenth harmonic at the test frequency (987 MHz). The PRF for the second test frequency shall be 98.8 MHz which will result in a eleventh harmonic at the test frequency (1087 MHz). The PRF for the third test frequency will be 99 MHz which will result in a twelfth harmonic at the test frequency (1188 MHz). This first test waveform shall not be dithered nor modulated. For this case, only one spectral line will fall within the IF passband, the IF signal will appear to be a continuous wave signal, and the receiver shall be tuned to the spectral line.

4.2 Test Waveform Two (TW2)

For the second test waveform, the basic PRFs of the UWB signals shall be the same as that described for the first test waveform but the pulses shall be randomly dithered to fill the IF passband. Therefore, the PRF of the pulses should be dithered +/- 0.2 MHz (which corresponds to approximately +/- 0.2%). This will result in a noise-like signal filling the receiver IF passband.

4.3 Test Waveform Three (TW3)

For the third test waveform, the PRF of the UWB signal shall be equal to the receiver IF bandwidth, which is 0.40 MHz, and the signal shall be dithered +/- 0.10 MHz (which corresponds to ± 25 % of the PRF). At the receiver, the interference will result in a noise-like signal filling half of the receiver IF passband. This condition will exist at any tuned frequency of the receiver across the entire tuning band of the receiver.

4.4 Test Waveform Four (TW4)

For the fourth test waveform, the PRF of the UWB signal shall be equal to the IF bandwidth of the receiver, which is 0.40 MHz, and the pulses shall not be dithered but the waveform shall be pulse modulated (PM) in a fashion similar to the actual TACAN signal. The resulting interfering signal will a modulated signal in the TACAN receiver IF passband similar to an actual TACAN signal and the UWB should be tuned for a maximum impact in the receiver.

4.5 Test Waveform Five (TW5)

For the fifth test waveform, the PRF of the UWB signal shall be 0.1 times the receiver IF bandwidth and the signal should not be dithered or modulated. Therefore, the PRF of the UWB shall be 40 kHz. For this case, the PRF will be slow relative to the IF response time so that individual pulses (with increased pulse widths and reduced peak power) will appear in the IF passband. For this waveform, approximately 10 spectral lines will appear in the IF passband.

4.6 Test Waveforms Six (TW6)

For the sixth test waveform, the PRF should be 10 times the receiver IF bandwidth or the highest UWB PRF not previously used which will result in a harmonic of the PRF in the receiver passband. For the TACAN system, the IF frequency is 0.40 MHz which would result in a PRF of 4 MHz. The UWB pulses should not be dithered or modulated. For this case, the PRF will be fast relative to the IF response time. Therefore, the signal will appear to be continuous and the effect will be that of a CW signal. Only one spectral line can fall within the IF passband and the receiver should be tuned to that spectral line.

4.7 Test Waveform Seven (TW7)

For the seventh test waveform, the PRF should be 0.01 of the receiver IF bandwidth. The IF frequency for the TACAN system is 0.40 MHZ which would result in a PRF of 4 kHz.

The signal should not be dithered or modulated. For this case, the PRF will be slow relative to the IF response time so that individual pulses, with increased pulse width and reduced peak power, will appear in the IF. For this waveform approximately 100 spectral lines will fall within the IF passband.

4.8 Test Waveform Eight (TW8)

The eighth test waveform is a stream of doublets with random initial phase orientation. The value of the symbol is determined by the phase relationship of the two pulses in the doublet as shown in Table 1. The two pulses in the doublet are separated by about 1 ns. Doublets themselves have burst repetition interval (BRI) of about 267 ns apart, allowing for a data rate of about 3.75 Mb/s for a high data rate or about 15.625 μs apart, allowing for a data rate of about 64 kb/s for a low data rate. The high data rate timing retains the ratio of peak to average spectral density described in the recent FCC ruling.

Table 1. Pseudorandom Noise Doublet Symbol Mapping

	Data = 0	Data = 1
PN = 0	+ +	+ -
PN = 1	- -	- +

Data is sent in packets of 1200 bits. This includes 1024 of payload data plus 176 bits of header. High data rate packets would be sent at the 3.75 Mp/s rate and last 320 μs. The packets would occur once every 8 ms and the packets would occur once every 8 ms. Low data rate packets would be sent at the 64 kp/s rate and last 18.75 ms and the packet would occur once every 468.75 ms. The payload data would be random, or all ones, or all zeros. The header data would be the same for each packet. Use all ones or all zeros for the header.

4.9 Test Waveform Nine (TW9)

The ninth test waveform is a stream of doublets with fixed initial phase orientation. The value of the symbol is determined by the phase relationship of the two pulses in the doublet as shown in Table 4.. The two pulses in the doublet are separated by about 5.708 ns. Doublets themselves have burst repetition interval (BRI) of about 17.123 ns apart, allowing for a data rate of about 58.4 Mb/s. The code has a maximum length 0f 1023 bits. This pulse spacing provides a spectrum with nulls every 175.2 MHz.

Table 2. Constant Phase Doublet Symbol Mapping

DATA	SYMBOL
0	- +
1	+ -

This waveform has three data rates based on the initial 58.4 Mb/s base data rate. The high data rate is simply a continuous stream at this rate. The medium data rate sends a burst of 1023 random symbols with a 175.17 μs BRI for a 10% burst duty factor. The low data rate sends a burst of 1023 random symbols with a 1.7517 ms BRI for a 1% burst duty factor.

4.10 Test Waveform Ten (TW10)

The tenth test waveform is an OOK pattern. Bit spacing is about 5 ns. Every 206 μs a training preamble of constant data rate pulses is sent. There is only one data rate for this waveform.

5.0 RECEIVER SUSCEPTIBILITY TEST

The objective of the receiver susceptibility tests is to obtain data that will provide useful information on the susceptibility of TACAN receivers to UWB interference. The tests will be performed using either one or two signals. With the one signal tests, a UWB interfering signal is input to the receiver under test and the output is observed. The receiver is considered to be susceptible if the UWB interfering signal produces a detectable change in the receiver output. No intended in-band signal is used for this test. For the TACAN receiver, the concern is that EMI may cause errors in the distance or azimuth measurements or may cause total loss of information in the receiver.

The two signal susceptibility tests described in this test plan require that the receiver desired signal and a UWB interfering signal be simultaneously injected into the receiver antenna port. The desired signal should be at a level that is referenced to a standard response level. The standard response is based on a receiver performance parameter that can be measured at the output of the receiver and it used to determine the receiver sensitivity that provides the basis for these susceptibility tests. For the TACAN receiver the standard response, and likewise the sensitivity, is usually defined in terms of the minimum discernable signal. The sensitivity is measured before the susceptibility tests are performed.

There are two approaches that may be used for the two signal susceptibility tests. For the first approach, the desired signal level is fixed at a level that is 6 dB above the “standard response acquisition threshold” (ACQ). The receiver susceptibility to UWB interference is determined by slowly increasing the UWB signal strength until the receiver can no longer maintain a standard response. The UWB interference level that degrades the receiver below the standard response condition is referred to as the Interference Upset Level (IUPSET). The UWB interfering signal is then increased to 20 dB above the Upset Level and slowly reduced until the standard response is reestablished. The level of the

UWB interfering signal at which the standard response is reestablished is the Reacquisition Level (REACQ). These levels describe the effect of the UWB interfering signal when the desired signal is close to the standard response threshold.

For the second approach, a high level UWB interfering signal (e.g., 20 dB above the receiver sensitivity) is injected and the desired signal level that is required for satisfactory operation of the receiver is determined. The information obtained from this test may be used to determine the reduction in range as a result of UWB interference. These levels are a better indication of the degradation resulting from UWB interference when there is a significant desired signal..

5.1 RECEIVER Sensitivity Measurement

The receiver sensitivity level is specified as the signal level required to create an appropriate standard response at the output of the receiver. The standard response level for TACAN systems is the minimum discernable signal. The nominal receiver sensitivity is –89 dBm at the input.

5.1.1 Receiver Sensitivity Measurement Objective

The objective of this test is to determine the receiver sensitivity (i.e., the minimum discernable input signal level).

5.1.2 Receiver Sensitivity Measurement Test Setup

The test set-up for the receiver sensitivity measurement is shown in Figure 1. A TACAN test set is used to generate the TACAN signal. A spectrum analyzer is used to monitor and measure the signal levels at the input to the TACAN receiver under test. A pre-amplifier connected at the input of the spectrum analyzer may be required to observe the signal during the sensitivity test. Alternatively, after the sensitivity level is established, the signal level can be raised by a known, fixed amount (e.g., 40 dB) to enable the measurement to be made.

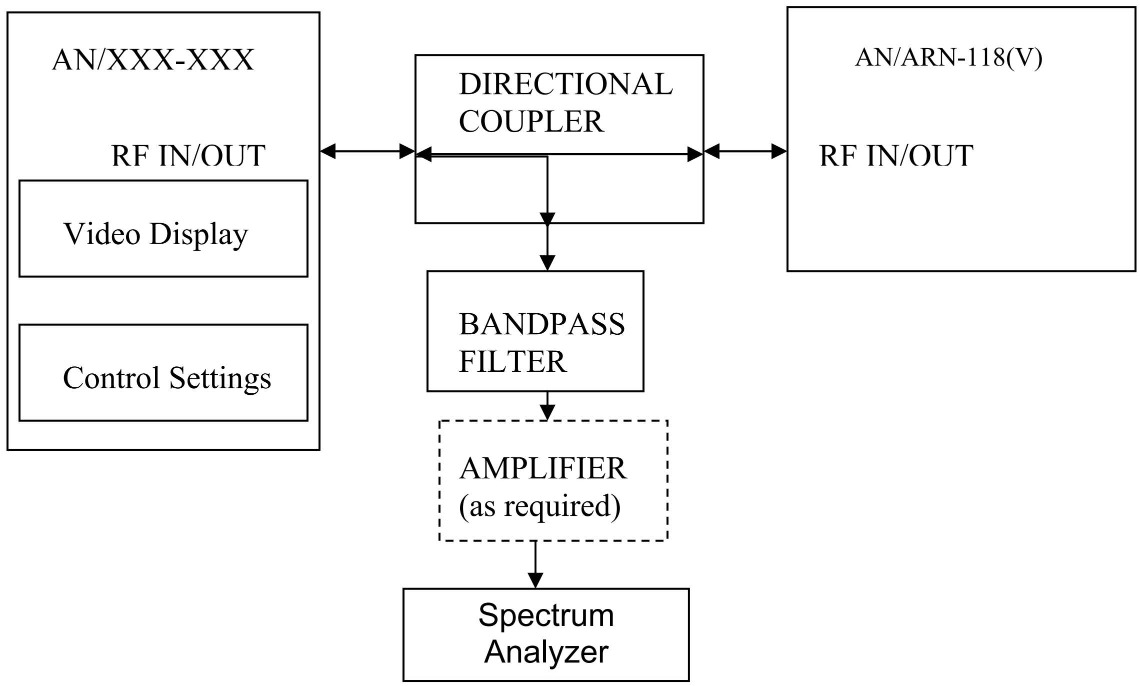


Figure 1. Receiver Sensitivity Test Set-Up

Spectrum analyzer levels shall be corrected for the pre-amplifier gain (if used) plus coupler and/or cable losses that exist in the measurement system. The receiver operation is verified to be satisfactory by monitoring the receiver output.

5.1.3 Receiver Sensitivity Test Procedure

The AN/ARN-118(V) shall be tested at each of the frequencies listed in Section 1.0 above. The general test procedure for determining receiver sensitivity is as follows:

42. Connect the AN/ARN-118(V) to the AN/XXX in accordance with normal test procedures as modified in Figure 1. Set AN/XXX to the desired mode and adjust for minimum power output. Verify that the receiver has not achieved a standard response condition for the low level signal.

43. Increase the AN/XXX output power level until the AN/XXX output monitor indicates a minimum discernable signal. Be sure to pause between each increase in signal power by an amount exceeding the maximum specified settling time for the receiver. Record on the data sheet in Table 3 the input power level at which the "standard response acquisition threshold" (ACQ) was first observed.

44. Increase the input power level an additional 10 dB above ACQ. This should result in a signal that is significantly above the MDS level.

45. Decrease the input power until the signal rate drops below the MDS. Record this level as the signal upset (SUPSET) threshold on the data sheet in Table 3.

46. Repeat steps 1 through 4 for each test frequency.

5.1.4 Receiver Sensitivity Measurement Output

The required results from the Receiver Sensitivity Test consist of documenting the "standard response acquisition threshold" (ACQ) and the signal upset (SUPSET) threshold on the appropriate line of the data sheet provided in Table 3. An average threshold value shall be specified if significant differences exist between the thresholds determined for each of the TACAN receiver test frequencies.

5.4 Receiver Susceptibility To White Noise

5.2.1 Receiver Susceptibility To White Noise Test Objective

The objective of this EMI test is to determine the susceptibility of an AN/ARN-118 (V) receiver (operating with a desired signal at the standard response level) to white noise interference. Susceptibility thresholds shall be determined by monitoring the output of the receiver and measuring the standard response level.

TABLE 3. DATA SHEET FOR SENSITIVITY MEASUREMENTS

Receiver: AN/ARN-118(V)
Frequency Band: 962 MHz to 1213 MHz
Test Frequencies: 987 MHz, 1087 MHz, 1188 MHz
Standard Response Criterion: MDS
Desired Signal Modulation: PPM
IF Bandwidth: 0.40 MHz
Sensitivity: -89 dBm

RCVR FRQ (MHz)	RCVR MODE	ACQ (dBm)	SUPSET (dBm)	NOTES (Record ACQ and SUPSET for each measurement here and average in column at left)
987	N/A			
1087	N/A			
1188	N/A			

NOTE: Sensitivity threshold levels are inherently statistical and thus this procedure shall be conducted multiple times to obtain a representative sample of the threshold level.

NOTE: Because the receive and the transmit signals use the same antenna, but different frequencies, it shall be necessary to isolate the test instrumentation from the effects of the transmit signal. This is best done through a combination of directional couplers and a very narrow band bandpass filter tuned to the TACAN interrogation frequency. The 3 dB bandwidth of the filter shall be less than or equal to 1 MHz, but greater than or equal to 0.40 MHz in order to allow the full interrogation signal to pass. The filter signal rejection at the TACAN transponder frequency shall be greater than or equal to 60 dB. If an amplifier is required, the gain shall be at least 10 dB greater than the attenuation of the directional coupler in order to get the minimum TACAN interrogation signal above the spectrum analyzer noise floor, typically -80 dBm/MHz.

5.2.2 Receiver Susceptibility To White Noise Test Setup

The test setup is shown in Figure 2.

5.2.3 Receiver Susceptibility To White Noise Test Procedure

The general test procedure for determining receiver susceptibility to white noise interference when the desired signal is at the standard response level is as follows:

41. Set the AN/XXX-XXX to the ACQ level shown in Table 3.

42. Activate the white noise source at a level that is at least 10 dB below the SUPSET level shown in Table 3. If interference to the desired signal is observed, reduce the white noise level to 10 dB below the lowest level at which interference is noted or maximum attenuation.

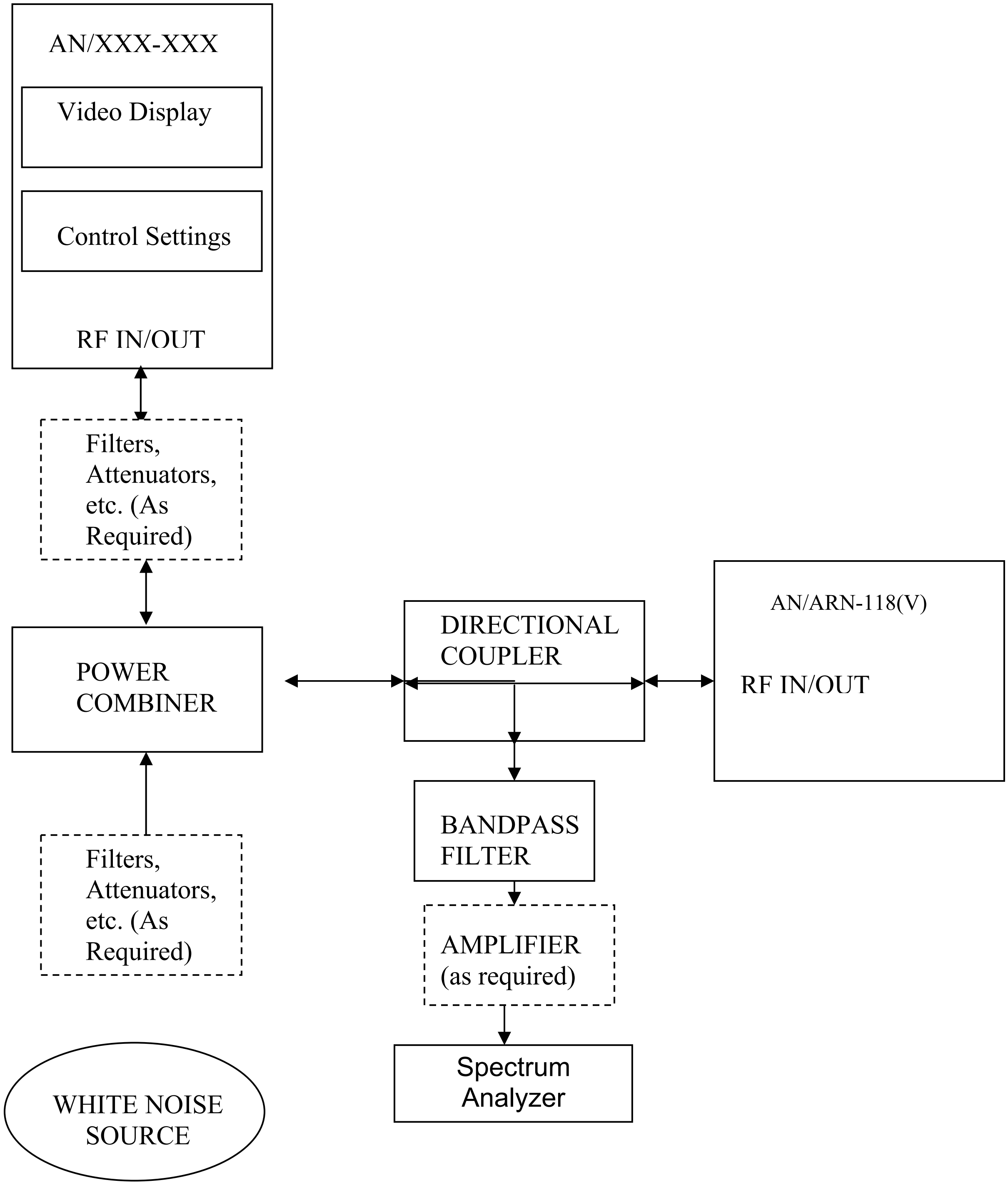


Figure 2. Conducted Susceptibility Test Set-Up-Two Signal Method

43. Slowly increase the white noise power level until there is an indication of impact on the receiver standard response condition (i.e., the signal is not discernable). The spectrum analyzer resolution bandwidth will not be the same as the IF bandwidth of the TACAN receiver, 400 kHz. The average noise level shall be measured using the spectrum analyzer with a resolution bandwidth (RBW) of 300 kHz (or greatest available spectrum analyzer RBW equal to or less than the TACAN IF passband). The spectrum analyzer Video Bandwidth [VBW] shall be equal to or greater than RBW. Empirical or calculated bandwidth correction factors shall be used to adjust the readings to the IF bandwidth of the receiver. Record this level as the "desired signal upset threshold" (WNUPSET) level in Table 4.

44. Increase the white noise level at least 10 dB above the WNUPSET level.

45. Slowly decrease the white noise level until the receiver reachieves the standard response condition. Record this level as the reacquisition threshold (WNREACQ) level. This level may be the same as WNUPSET.

46. Repeat Steps 1 through 5 for each receiver operating frequency.

TABLE 4. DATA SHEET FOR WHITE NOISE TESTS

Receiver: AN/ARN-118(V)
Frequency Band: 962 MHz to 1213 MHz
Test Frequencies: 987 MHz, 1087 MHz, 1188 MHz
Standard Response Criterion: MDS
Desired Signal Modulation: PPM
IF Bandwidth: 0.40 MHz
Sensitivity: -89 dBm

	FREQUENCY (MHz)	SIGNAL LEVEL (dBm)	NOISE LEVEL (dBm)
ACQ	987		N/A
WNUPSET	987		
WNREACQ	987		
ACQ	1087		
WNUPSET	1087		
WNREACT	1087		
ACQ	1188		
WNSET	1188		
WNREACT	1188		

5.2.4 Receiver Susceptibility To White Noise Test Output

The required results from the Receiver Susceptibility To White Noise Test consist of documenting the “standard response acquisition threshold” (ACQ), the “desired signal upset threshold” (WNUPSET) and the reacquisition threshold (WNREACQ) on the appropriate lines of the data sheet provided in Table 4 for the appropriate TACAN frequency.

5.3 One Signal Receiver Susceptibility

5.3.1 One Signal Receiver Susceptibility – Test Objective

The objective of this test is to determine whether a UWB interfering signal will create a minimum discernable signal at the output of a TACAN receiver.

5.3.2 One Signal Receiver Susceptibility – Test Setup

The test setup is the same as the one shown in Figure 3. However, the test set is not providing a signal to the TACAN receiver.

5.3.3 One Signal Receiver Susceptibility –Test Procedures

11.Set the test set so it is not providing a signal to the TACAN receiver. If necessary, turn the transponder OFF.

12.Activate the UWB interference signal source with the first UWB test waveform at a maximum power level.

13.Monitor the output of the TACAN receiver and note if there are any discernable signals present at the output of the receiver.

14.If there are any discernable signals at the output of the TACAN receiver, reduce the level of the UWB interfering signal until there is a minimum discernable signal at the receiver output. Record this as the MDS in Table 5.

15.Repeat Steps 1 through 4 for the other UWB waveforms.

6. Repeat steps 1 through 5 at each test frequency.

5.3.4 One Signal Receiver Susceptibility Output

The required results from the One Signal Receiver Susceptibility Test consist of documenting the “Minimum Discernable Signal” (MDS) on the data sheet provided in Table 5 for the appropriate TACAN frequency.

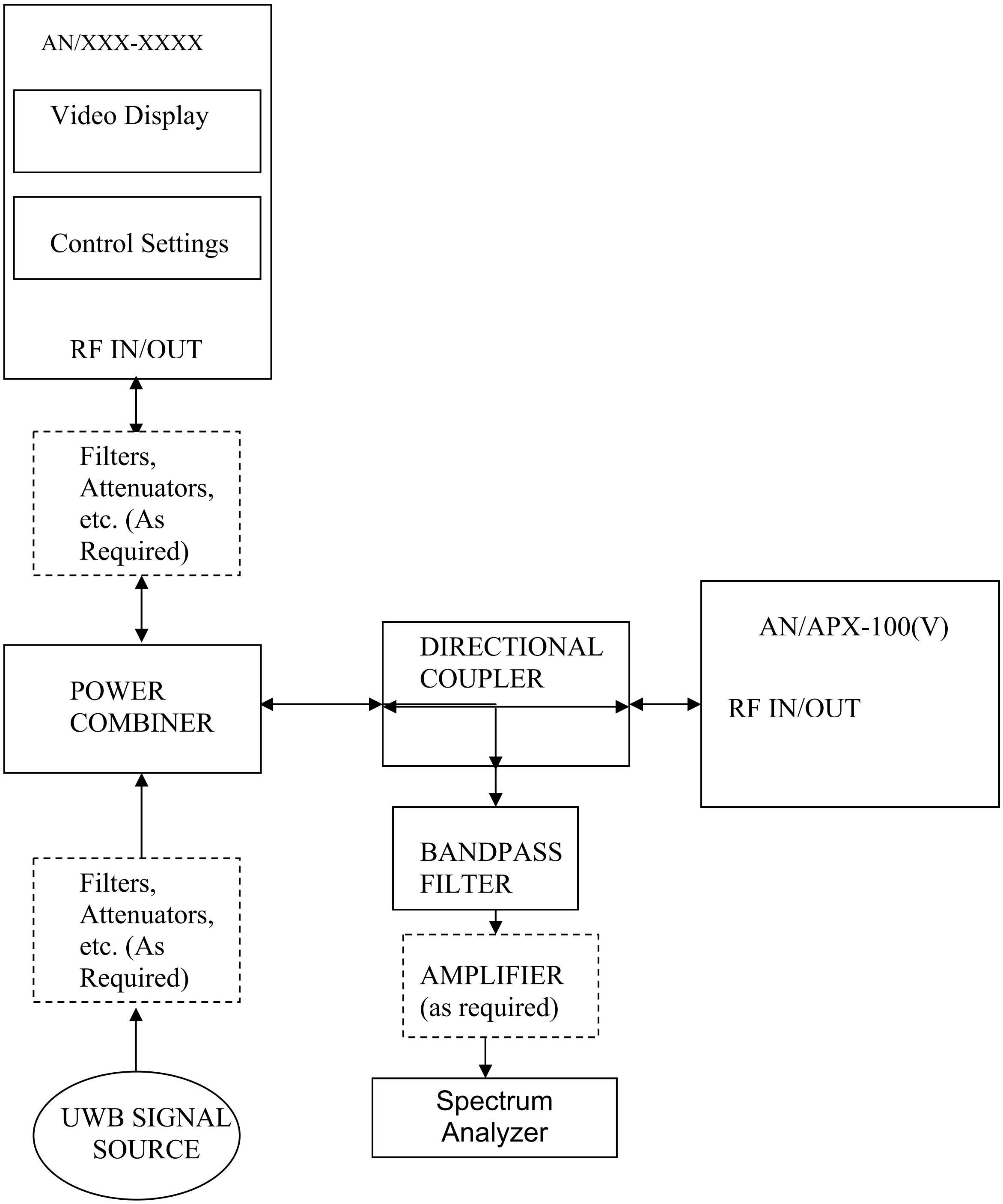


Figure 3. Conducted Susceptibility Test Set-Up-Two Signal Method

TABLE 5. DATA SHEET FOR ONE SIGNAL SUSCEPTIBILITY TEST

Receiver: AN/ARN-118(V)
Frequency Band: 962 MHz to 1213 MHz
Test Frequencies: 987 MHz, 1087 MHz, 1188 MHz
Standard Response Criterion: MDS
Desired Signal Modulation: PPM
IF Bandwidth: 0.40 MHz
Sensitivity: -89 dBm

RX FRQ (MHz)	UWB SIGNAL	PRF (MHz)	UWB MOD	MDS (dBm)
987	1	98.7	NONE	
	2	98.7	DITHERED ± 0.2%	
	3	0.40	DITHERED ± 25%	
	4	0.40	PPM	
	5	0.04	NONE	
	6	4.0	NONE	
	7	0.004	NONE	
	8			
	9			
	10			

Note that the spectrum analyzer resolution and video bandwidths will not be the same as the RF bandwidth of the UWB waveform. The resolution bandwidth (RBW) of the spectrum analyzer shall be 300 kHz or the spectrum analyzer RBW closest to, but not exceeding, 400 kHz. The spectrum analyzer video bandwidth (VBW) shall be equal to or greater than the RBW. Empirical or calculated bandwidth correction factors shall be used to adjust the measurement of the UWB waveform to the IF bandwidth of the receiver. Average measurements shall be made for all of the test waveforms except for Waveform 5 which shall be made as a peak measurement.

5.4 Two Signal Receiver Susceptibility - Standard Response Desired Signal

5.4.1 Two Signal Susceptibility - Standard Response Desired Signal Test Objective

The objective of this EMI test is to determine the susceptibility of an AN/ARN-118 (V) receiver (operating with a desired signal at the standard response level) to UWB interfering signals. Susceptibility thresholds shall be determined by monitoring the output of the receiver and measuring the standard response level.

5.4.2 Two Signal Receiver Susceptibility - Standard Response Desired Signal Test Setup

The test setup is shown in Figure 3.

5.4.3 Two Signal Receiver Susceptibility - Standard Response Desired Signal Test Procedure

The general test procedure for determining receiver susceptibility to interference when the desired signal is at the standard response level is as follows:

15. Set the TACAN receiver to the selected test frequency and adjust the signal from the test set so the power level is 6 dB above the ACQ level recorded in Table 3. The desired signal should be modulated in the normal manner used by the receiver. Verify that the desired signal results in a discernable signal at the receiver output

16. Decrease the desired signal to a level that is 6 dB above the "desired signal upset threshold" (SUPSET) recorded in Table 3. Record this level as the Desired Signal Level (DSL) in Table 6 for the specified UWB waveform. Verify that the receiver output exceeds the standard response condition.

17. Activate the UWB interference signal source with one of the UWB test waveforms as a level that is at least 20 dB below SUPSET.

18. Increase the UWB interference signal power level until there is an indication of impact on the receiver standard response condition (i.e., a decrease in the reply rate). Record this level as the "interfering signal upset threshold" (IUPSET) level in Table 6. Record IUPSET – DSL as the interference-to-signal ratio (I/S).

19. Adjust the desired signal level to 6 dB above the ACQ level recorded in Table 3. Record this level as the "desired signal level" (DSL) on the second row for the selected UWB waveform.

20. Set the UWB interfering signal to the maximum level available. If the standard response condition is impacted, slowly decrease the UWB interference signal power until the receiver returns to a standard response. Record this interference level in Table 6 as the "interfering signal reacquisition threshold" (REACQ) level. Record REACQ – DSL as the I/S ratio in Table 6.

21. Repeat Steps 1 through 6 for each UWB waveform.

22. Repeat Steps 1 through 7 for each TACAN test frequency.

5.4.4 Two Signal Receiver Susceptibility - Standard Response Desired Signal Test Output

The required results from the two signal EMI tests consist of recording the desired signal level for the "standard response acquisition threshold," the "desired signal upset threshold," and calculating the difference between these levels as the Interference-to-Signal Ratio (I/S). Also, the interfering signal level for the "interfering signal upset threshold," the "reacquisition threshold," and the calculated the difference between these levels as the Interference-to-Signal Ratio (I/S) shall be recorded on the appropriate lines of the applicable data sheet for each UWB interference signal waveform and each test frequency of the receiver.

TABLE 6
TWO SIGNAL SUSCEPTIBILITY - STANDARD RESPONSE DESIRED SIGNAL

Receiver: AN/ARN-118(V)
Frequency Band: 962 MHz to 1213 MHz
Test Frequency: 987 MHz
Standard Response Criterion: MDS
Desired Signal Modulation: PPM
IF Bandwidth: 0.40 MHz
Sensitivity: - 89 dBm

UWB SIGNAL	PRF (MHz)	UWB MOD	DSL (dBm)	IUPSET (dBm)	REACQ (dBm)	I/S (dB)
1	98.7	NONE			X	
1	98.7	NONE		X		
2	98.7	DITHERED ± 0.2%			X	
2	98.7	DITHERED ±0.2 %		X		
3	0.40	DITHERED ± 25%			X	
3	0.40	DITHERED ± 25%		X		
4	0.40	PPM			X	
4	0.40	PPM		X		
5	0.040	NONE			X	
5	0.040	NONE		X		
6	4.0	NONE			X	
6	4.0	NONE		X		
7	0.004	NONE			X	
7	0.004	NONE		X		
8					X	
8				X		
9					X	
9				X		
10					X	

UWB SIGNAL	PRF (MHz)	UWB MOD	DSL (dBm)	IUPSET (dBm)	REACQ (dBm)	I/S (dB)
10				X		

Note that the spectrum analyzer resolution and video bandwidths will not be the same as the RF bandwidth of the UWB waveform. The resolution bandwidth (RBW) of the spectrum analyzer shall be 300 kHz or the spectrum analyzer RBW closest to, but not exceeding, 400 kHz. The spectrum analyzer video bandwidth (VBW) shall be equal to or greater than the RBW. Empirical or calculated bandwidth correction factors shall be used to adjust the measurement of the UWB waveform to the IF bandwidth of the receiver. Average measurements shall be made for all of the test waveforms except for Waveform 5 which shall be made as a peak measurement.

5.5 Two Signal Receiver Susceptibility – High Level UWB Signal

5.5.1 Two Signal Receiver Susceptibility –High Level UWB Signal Test Objective

The objective of this test is to determine the desired signal level that is required for the receiver to operate in a satisfactory manner with a high level UWB interfering signal (e.g., 20 dB above the receiver sensitivity) present.

5.5.2 Two Signal Receiver Susceptibility –High Level UWB Signal Test Setup

The test setup is basically the same as the setup shown in Figure 3. The only differences between this test and the previous test (i.e., the two signal test with the desired signal set at a standard response level) are the levels of the desired and interfering signals.

5.5.3 Two Signal Receiver Susceptibility – High Level UWB Signal Test Procedure

The test procedure for determining the desired signal level required for satisfactory operation when a high level interfering signal is present is as follows:

33. Set the TACAN receiver to one of the test frequencies. Select a UWB signal waveform.

34. Adjust the UWB signal so the inband components of the UWB signal (i.e., the UWB components measured in a bandwidth equal to the IF bandwidth of the receiver or adjusted to the IF bandwidth by using a bandwidth correction factor) are 20 dB above the receiver sensitivity or are at the maximum power available from the pulse generator. Record this level in Table 7 as the Interference Signal Level (ISL) in dBm.

35. Increase the desired signal level until the receiver achieves a standard response condition. Record the desired signal level for acquisition of a standard response condition (ACQ) on the appropriate line for the selected UWB waveform and TACAN frequency in Table 7. On the same line calculate the Interference-to-Signal Ratio (I/S) as ISL – ACQ.

36. Decrease the desired signal level until upset occurs. Record the desired signal level for upset of the standard response condition (SUPSET) on the appropriate line for the selected UWB waveform and TACAN frequency in Table 7.

37. On the same line calculate the Interference-to-Signal Ratio (I/S) as ISL – SUPSET.

38. Repeat Steps 1 through 5 for each of the UWB waveforms.

39. Repeat Steps 1 through 6 for each TACAN test frequency.

5.5.4 Two Signal Receiver Susceptibility – High Level UWB Signal Test Output

Record the interfering signal level (ISL), the desired signal levels for the conditions where "acquisition" (ACQ) and "upset" (SUPSET) occurred and the signal to interference ratios (S/I) on the appropriate lines on the applicable data sheet provided in Table 7.

TABLE 7. TWO SIGNAL RECEIVER SUSCEPTIBILITY – HIGH LEVEL UWB SIGNAL

Receiver: AN/ARN-118(V)
Frequency Band: 962 MHz – 1213 MHz
Test Frequencies: 987 MHz
Standard Response Criterion: MDS
Desired Signal Modulation: PPM
IF Bandwidth: 0.40 MHz
Sensitivity: - 89 dBm

UWB SIGNAL	PRF (MHz)	UWB MOD	ISL (dBm)	ACQ (dBm)	SUPSET (dBm)	I/S (dB)
1	98.7	NONE			X	
1	98.7	NONE		X		
2	98.7	DITHERED ± 0.2%			X	
2	98.7	DITHERED ± 0.2%		X		
3	0.40	DITHERED ± 25%			X	
3	0.40	DITHERED ± 25%		X		
4	0.40	PPM			X	
4	0.40	PPM		X		
5	0.04	NONE			X	
5	0.04	NONE		X		
6	4.0	NONE			X	
6	4.0	NONE		X		
7	0.004	NONE			X	
7	0.004	NONE		X		
8					X	
8				X		
9					X	
9				X		

UWB SIGNAL	PRF (MHz)	UWB MOD	ISL (dBm)	ACQ (dBm)	SUPSET (dBm)	I/S (dB)
10					X	
10				X		

Note that the spectrum analyzer resolution and video bandwidths will not be the same as the RF bandwidth of the UWB waveform. The resolution bandwidth (RBW) of the spectrum analyzer shall be 300 kHz or the spectrum analyzer RBW closest to, but not exceeding, 400 kHz. The spectrum analyzer video bandwidth (VBW) shall be equal to or greater than the RBW. Empirical or calculated bandwidth correction factors shall be used to adjust the measurement of the UWB waveform to the IF bandwidth of the receiver. Average measurements shall be made for all of the test waveforms except for Waveform 5 which shall be made as a peak measurement.